DIVISION OF
CORPORATION FINANCE

UNITED STATES
SECURITIES AND EXCHANGE COMMISSION
WASHINGTON, D.C. 20549-3010

No Act

March 28, 2006

David F. Taylor
Locke Liddell & Sapp LLP
3400 JPMorgan Chase Tower
600 Travis Street
Houton, TX 77002-3095

Act: 1934
Section:
Rule: 14A-8
Public
Availability: 3/28/2006

Re: Synagro Technologies, Inc.
Incoming letter dated February 7, 2006

Dear Mr. Taylor:

This is in response to your letter dated February 7, 2006 concerning the shareholder proposal submitted to Synagro by the Mercy Investment Program; the Ursuline Sisters of Tildonk, U.S. Province; and Sustainable South Bronx. Our response is attached to the enclosed photocopy of your correspondence. By doing this, we avoid having to recite or summarize the facts set forth in the correspondence. Copies of all of the correspondence also will be provided to the proponents.

In connection with this matter, your attention is directed to the enclosure, which sets forth a brief discussion of the Division's informal procedures regarding shareholder proposals.

Sincerely,

Eric Finseth
Attorney-Adviser

Enclosures

cc: Valerie Heinonen, o.s.u.
Consultant, Corporate Social Responsibility
Mercy Investment Program
205 Avenue C, #10E
New York, NY 10009

Valerie Heinonen, o.s.u.
Ursuline Sisters of Tildonk
United States Province
81-15 Utopia Parkway
Jamaica, NY 11432-1308

cc: Elena Conte
Solid Waste and Energy Coordinator
Sustainable South Bronx
890 Garrison Ave.
The Bronx, NY 10474

LOCKE LIDDELL & SAPP LLP
ATTORNEYS & COUNSELORS
3400 JPMORGAN CHASE TOWER
600 TRAVIS STREET
HOUSTON, TEXAS 77002-3095
AUSTIN • DALLAS • HOUSTON • NEW ORLEANS
(713) 226-1200
Fax: (713) 223-3717
www.lockeliddell.com

February 7, 2006

By Federal Express

Office of Chief Counsel
Division of Corporation Finance
U.S. Securities and Exchange Commission
450 Fifth Street, N.W.
Washington, DC 20549

Re: Proposal Submitted by Mercy Investment Program, the Ursuline Sisters of Tildonk and Sustainable South Bronx.

Ladies and Gentlemen:

We are writing on behalf of our client, Synagro Technologies, Inc., a Delaware corporation ("Synagro"). Synagro has received from Mercy Investment Program, the Ursuline Sisters of Tildonk and Sustainable South Bronx, three of its stockholders, identical letters requesting that a proposal and accompanying supporting statement (the "Proposal") be included in Synagro's proxy materials for its next Annual Meeting of Stockholders. A copy of the Proposal is attached hereto as Exhibit A. Synagro expects to file its definitive proxy materials on or about April 28, 2006.

On behalf of Synagro, we respectfully notify the staff of the Division of Corporation Finance of the U.S. Securities and Exchange Commission (the "Commission"), Mercy Investment Program, the Ursuline Sisters of Tildonk and Sustainable South Bronx, to whom we are today sending copies of this letter, that Synagro intends to omit the Proposal from its proxy materials for the reasons set forth below. In accordance with Rule 14a-8 of the Securities Exchange Act of 1934, as amended, we enclose six (6) copies of this letter (which constitutes both the required statement of reasons and supporting opinion of counsel) and the Proposal. Synagro respectfully requests the concurrence of the Commission that no enforcement action will be recommended if Synagro omits the Proposal from its proxy materials.

Factual Background

The Proposal requests that the following matter be submitted to a vote of the stockholders at the next Annual Meeting of the Stockholders: "Resolved: shareholders request the Board of Directors to report, by January, 2007, at reasonable cost and omitting proprietary information, on environmental, health and safety impacts of New York Organic Fertilizer Company (NYOFCo), [a facility] operated by Synagro, on the South Bronx, New York community." The Proposal also includes a supporting statement, discussed below, that indicates the report should include total releases in Hunts Point and the South Bronx, the impact of NYOFCo's operations on the health and safety of residents in Hunts Point and the South Bronx, and Synagro's integration of community environmental accountability into its procedures and practices. Synagro originally received the

Proposal from Mercy Investment Program on December 27, 2005 and from the Ursuline Sisters of Tildonk and Sustainable South Bronx on December 28, 2005.

Discussion of Reasons for Omission

Synagro believes that the entire Proposal may be omitted (1) pursuant to Rule 14a-8(i)(5) because portions of the Proposal are not relevant and (2) pursuant to Rule 14a-8(i)(10) because the relevant portions of the Proposal have been substantially implemented. Additionally, Synagro believes that one of the co-sponsors of the Proposal, Sustainable South Bronx, may be omitted pursuant to Rule 14a-8(b) because Sustainable South Bronx does not hold at least one percent, or $2,000 in market value, of Synagro's outstanding securities.

(1) Relevancy – Rule 14a-8(i)(5)

Synagro believes that the entire Proposal may be omitted pursuant to Rule 14a-8(i)(5) because portions of the Proposal are not relevant. Rule 14a-8(i)(5) provides that a company may exclude a stockholder proposal if "the proposal relates to operations which account for less than 5 percent of the company's total assets at the end of its most recent fiscal year, and for less than 5 percent of its net earnings and gross sales for its most recent fiscal year, and is not otherwise significantly related to the company's business."

Relief can be granted under Rule 14a-8(i)(5) when a proposal addresses conduct in which a company does not engage. See, e.g. College Retirement Equities Fund (May 3, 2004) (permitting exclusion of a proposal requesting a warning regarding the offering of an insurance product, where the company was not the sponsor of the insurance product); The Proctor & Gamble Company (Aug. 11, 2003) (permitting exclusion of a proposal requesting adoption of a policy forbidding embryonic stem cell research, where the company did not engage in embryonic stem cell research). Similarly, the Proposal submitted to Synagro may be excluded because it requests information under environmental reporting standards which are not applicable to NYOFCo's operations.

The Proposal requests that Synagro report on the environmental, health and safety impacts of NYOFCo, including NYOFCo's total releases in Hunts Point and the South Bronx. In particular, the Proposal asks for NYOFCo's releases under the EPA's 1998 proposed rules for national emission standards at Public Owned Treatment Works ("POTWs"). This request is not relevant because NYOFCo is not a POTW and does not report its releases under the EPA's proposed standards for POTWs. Instead, under its Title V reporting requirements, NYOFCo is regulated under the Clean Water Act, Clean Air Act, New York State Solid Waste Regulations and local Fire Department regulations. Synagro provides periodic reports regarding its releases in Hunts Point and the South Bronx under the standards required by its permits. A list of publicly available reports is attached as Exhibit B. The EPA inspects the facility every five years to examine bulk chemical storage and biosolids management. The most recent EPA inspection was conducted in August 2005, at which time NYOFCo was found to be in complete compliance, with only filing and administrative corrections needed.

It is the position of Synagro that part of the Proposal is not relevant because NYOFCo is not a POTW regulated by the EPA's national emission standards. Therefore, Synagro believes that it may exclude the Proposal as not relevant under Rule 14a-8(i)(5).

(2) Substantially Implemented – Rule 14a-8(i)(10)

Synagro believes that the entire Proposal may be omitted pursuant to Rule 14a-8(i)(10) because the relevant portions of the Proposal have been substantially implemented. Rule 14a-8(i)(10) provides that a company may exclude a stockholder proposal if "the company has already substantially implemented the proposal," thereby rendering it moot.

Under the standard expressed by the Commission in Exchange Act Release No. 34-19135 (August 16, 1983), a proposal may be omitted if it has been "'substantially implemented by the issuer,'" though it has not been "fully effected." In establishing this subjective interpretative position, the Commission "determined that the previous formalistic application of this provision defeated its purpose." A company has substantially implemented a shareholder proposal if the company's relevant policies, practices and procedures "compare favorably with the guidelines of the proposal." Texaco, Inc. (March 28, 1991). When a company has the essential objectives of a policy in place, or has policies, procedures and standards concerning the subject matter of the proposal in place, the Commission has consistently found that the proposal has been substantially implemented and can be omitted under Rule 14a-8(i)(10). See, e.g. The Talbots, Inc. (April 5, 2002) (permitting exclusion of a proposal requesting implementation of a code of corporate conduct based on United Nations standards, where the company revised its social and human rights policy and published an annual report); The Gap, Inc. (March 16, 2001) (permitting exclusion of a proposal requesting a report on the child labor practices of the company's suppliers when the company had an established code of vendor conduct and disseminated detailed labor information to stockholders). Likewise, Synagro's current disclosures and required filings concerning environmental, health and safety information compare favorably with the information requested in the Proposal.

In addition to information on NYOFCo's total releases, as discussed above, the Proposal requests that Synagro report on the impact of NYOFCo's operations on the health and safety of residents in Hunts Point and the South Bronx and Synagro's integration of community environmental accountability into its procedures and practices. However, as demonstrated below, Synagro has already substantially reported and disclosed the information requested in the Proposal.

Synagro has submitted several reports pursuant to its ongoing regulation by environmental agencies that address the possible impact of NYOFCo's operations on the health and safety of individuals in Hunts Point and the South Bronx:

- NYOFCo provided an Environmental Assessment to the Albany office of the New York State Department of Environmental Conservation, the state's environmental and regulatory agency (the "DEC"). This report is in the public record, and a copy can be provided to the Commission upon request.
- NYOFCo regularly files AGC-1 reports with the DEC. The DEC's Air Guide provides guidance for the control of toxic ambient air contaminants. After every compliance stack test, data from that sample is entered into the AG-1 software program, which produces a report modeled on the impact of the emissions on the most sensitive person closest to the facility. An AGC-1 report is attached hereto as Exhibit C, and additional reports can be provided to the Commission upon request. These reports are publicly available, and a copy was given to Sustainable South Bronx, one of the Proposal's co-sponsors, in April 2004.

- NYOFCo is required to conduct odor surveys in response to complaints about odors emanating from the facility. The findings are reported to the DEC on a biweekly basis and are publicly available. Copies of these reports can be provided to the Commission upon request.
- Pursuant to its Title V permit, NYOFCo was required by the DEC to conduct literature research regarding molds, spores, bioaerosols and pathogens from operations similar to NYOFCo. NYOFCo compiled its results into a report for the DEC, attached hereto as Exhibit D. This report is in the public record and was made available to Sustainable South Bronx at a community meeting. The DEC reviewed the report and provided NYOFCo with a letter indicating that the facility did not pose a threat to the community. A copy of the letter is attached hereto as Exhibit E.

In addition to Synagro's reporting efforts, both the EPA and the New York State Department of Health have conducted independent environmental monitoring in the South Bronx. Their findings were released to the public, and copies of the reports are attached hereto as Exhibit F and Exhibit G. Collectively, the information in these reports concerning NYOFCo's impact on the health and safety of local residents compares favorably with the information requested in the Proposal.

Synagro has also provided information regarding the integration of community environmental accountability into its environmental management procedures and business practices. These procedures and practices are set forth in Synagro's Best Practices Manual for Occupational Safety, Health and Transportation. Applicable sections of the Best Practices Manual are attached hereto as Exhibit H, and a copy of the entire manual can be provided to the Commission upon request. Additionally, Synagro's philosophy on community environmental accountability is reflected in its current practices at the NYOFCo facility:

- NYOFCo has taken proactive steps to protect the health and safety of residents of Hunts Point and the South Bronx.
  - NYOFCo installed expensive engineering controls at the facility that help ensure compliance with permit emission levels.
  - NYOFCo contracts with an independent company to perform monthly odor surveys that supplement NYOFCo's own odor monitoring.
  - NYOFCo recently donated more than $100,000 to fund a health initiative through the Medical and Health Research Association of New York City, a non-profit organization dedicated to improving the health and well-being of low income, high risk New Yorkers.

- NYOFCo has become more involved with the community in order to open a dialogue with residents of Hunts Point and the South Bronx.
  - A NYOFCo representative attends Bronx Community Board 2's environmental meetings.
  - NYOFCo has formed a community panel of several local organizations, including Proposal co-sponsor Sustainable South Bronx.
  - NYOFCo releases an informational and educational newsletter, available in both English and Spanish, to the community on a quarterly basis. A copy of the newsletter is attached hereto as Exhibit I.

Both the Best Practices Manual and Synagro's current business practices in the community illustrate Synagro's integration of community environmental accountability into its business procedures and practices, as requested in the Proposal.

It is the position of Synagro that it has already provided the environmental, health and safety information requested in the Proposal. Therefore, Synagro believes that it may exclude the Proposal as substantially implemented under Rule 14a-8(i)(10).

(3) $2,000 or One Percent Requirement – Rule 14a-8(b)

Synagro believes that one of the co-sponsors of the Proposal, Sustainable South Bronx, may be omitted pursuant to Rule 14a-8(b) because Sustainable South Bronx does not hold at least $2,000 in market value, or one percent, of Synagro's securities entitled to be voted on the Proposal at the meeting.

Rule 14a-8(b) requires that a stockholder be eligible to submit a proposal. Rule 14a-8(b)(1) states "In order to be eligible to submit a proposal, you must have continuously held at least $2,000 in market value, or 1%, of the company's securities entitled to be voted on the proposal at the meeting for at least one year by the date you submit the proposal."

According to the letter accompanying Sustainable South Bronx's Proposal, included in Exhibit A, Sustainable South Bronx is the beneficial owner of 50 shares of Synagro stock. Sustainable South Bronx's 50 shares represent less than one percent of Synagro's outstanding shares of common stock, which total more than 73,000,000 shares. Sustainable South Bronx's 50 shares also represent less than $2,000 in market value of Synagro's outstanding securities. To determine whether the $2,000 requirement is satisfied, the Commission looks at whether, on any date within the 60 calendar days before the date the stockholder submits the Proposal, the stockholder's investment is valued at $2,000 or greater. Staff Legal Bulletin No. 14, Item C1(a) (July 13, 2001). As shown in Exhibit J, the 52-week range of Synagro's stock price is $3.38 to $5.42. Even assuming that the 52-week high occurred within the 60 calendar days before the date Sustainable South Bronx submitted the Proposal, Sustainable South Bronx does not hold at least $2,000 in market value of Synagro's outstanding securities.

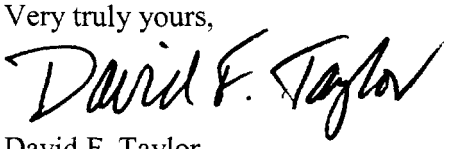
Rule 14a-8(f) allows a company to forego providing notice of a deficiency if the Proposal has a deficiency that cannot be corrected. One example of an incurable circumstance is where a stockholder has indicated that it does not own at least $2,000 in market value, or one percent, of the company's securities. Staff Legal Bulletin No. 14, Item C6 (July 13, 2001). Accordingly, Synagro was not required to, and did not, provide Sustainable South Bronx with notice of its failure to meet the eligibility requirements of Rule 14a-8(b). However, pursuant to Rule 14a-8(j), Synagro is providing notice of its intention to omit Sustainable South Bronx from the Proposal by sending a copy of this letter to the stockholder.

Since Sustainable South Bronx is the beneficial owner of only 50 shares of Synagro stock, Sustainable South Bronx does not hold at least $2,000 in market value, or one percent, of Synagro's securities entitled to be voted on the Proposal at the meeting. Therefore, Sustainable South Bronx may be omitted from the Proposal pursuant to Rule 14a-8(b).

Request

For the foregoing reasons, Synagro respectfully requests that the Commission confirm that it will not recommend enforcement proceedings if Synagro omits the Proposal from its 2006 proxy materials or omits Sustainable South Bronx as a co-sponsor of the Proposal. Should you have any questions or comments regarding the foregoing, please do not hesitate to contact the undersigned at 713/226-1496. Please acknowledge receipt of this letter and enclosures by stamping the enclosed additional copy of this letter and returning it in the enclosed self-addressed stamped envelope. We appreciate your timely attention to this request.

Very truly yours,



David F. Taylor

Enclosure

cc: ***Via Facsimile***
Mr. Robert C. Boucher
Synagro Technologies, Inc.
1800 Bering Drive #1000
Houston, Texas 77057

By Certified Mail
Ms. Valerie Heinonen
Mercy Investment Program
205 Avenue C, #10E
New York, NY 10009

By Certified Mail
Ms. Valerie Heinonen
Ursuline Sisters of Tildonk
81-15 Utopia Parkway
Jamaica, NY 11432-1308

By Certified Mail
Ms. Elena Conte
Sustainable South Bronx
890 Garrison Ave.
The Bronx, NY 10474

Michelle Earley (Firm)
Mechelle Smith (Firm)

Exhibit A

See attached.

Mercy Investment Program

Valerie Heinonen, o.s.u., Consultant, Corporate Social Responsibility
205 Avenue C, #10E ~ New York, NY 10009
Phone/Fax 212-674-2542 ~ E-mail heinonenv@juno.com

December 20, 2005

Robert C. Boucher, President and CEO
Synagro Technologies, Inc.
1800 Bering Drive #1000
Houston, TX 77057

Dear Mr. Boucher:

On behalf of the Mercy Investment Program, I am authorized to submit the following resolution which requests the Board of Directors to report to shareholders certain information on how our company ensures that it is accountable for NYOFCO's environmental impacts in the South Bronx, New York City community in which it operates, for inclusion in the proxy statement of the next annual meeting under Rule 14 a-8 of the General Rules and Regulations of the Securities Exchange Act of 1934. Mercy Investment Program is a sponsor of this resolution with Sustainable South Bronx and other faith-based investors.

Mercy Investment Program is a socially responsible pooled investment program for the Sisters of Mercy of the Americas. One of the priorities for the Sisters of Mercy is care for our environment. We are concerned not only for appropriate use of our natural resources of land and water but also the impact of waste and hazardous materials on local communities where waste facilities are located. While we understand that solid wastes must be treated, we know that such facilities are commonly located in communities of low income people of color. The perception is that such communities will have little or no political voice to ensure that the technology and architecture installed prevents harm to the people living close by. Your responses to date have not assured us that you are operating in a manner, which protects the South Bronx population, the river or land of the NYOFCO location. We remain open to meeting with you to discuss the concerns raised in our resolution.

Mercy Investment Program is the beneficial owner of 800 shares of Synagro stock. Verification of ownership follows. We plan to hold the stock at least until the time of the annual meeting and will be present in person or by proxy at that meeting.

Yours truly,

Valerie Heinonen, o.s.u.

Valerie Heinonen, o.s.u.

Report on NYOFCo's Environmental Impacts

Resolved: shareholders request the Board of Directors to report, by January, 2007, at reasonable cost and omitting proprietary information, on environmental, health and safety impacts of New York Organic Fertilizer Company (NYOFCo), operated by Synagro, on the South Bronx, New York community.

Supporting statement

Corporations have a moral and legal responsibility to account for impacts—not only on ecosystems, but also on health and safety of communities hosting their facilities. Synagro operates NYOFCo pursuant to a New York City contract, our company's largest municipal services contract.

Hunts Point, NYOFCo's location, is a one square mile peninsula in southeastern Bronx County. It is one of the poorest Congressional Districts in the U.S., where incidence of childhood asthma is among the highest in the nation. This community bears heavy environmental burdens from local industrial and commercial facilities that daily bring thousands of diesel trucks through the neighborhood.

Since opening, NYOFCo has added to environmental burdens of Hunts Point and the surrounding area. Even after our company acquired NYOFCo operations in 2000, residents continued complaining that noxious odors emanate from the plant.[1, 3] Odors from NYOFCo's smoke stacks, only 163 feet tall, are carried to nearby Public School 48 that sits on higher ground.

NYOFCo's safety record also causes alarm in the community and concern among shareholders due to a series of explosions and fires,[3] most recently in February 2005. Facility inspections and review of NYOFCo's stack tests in 2003-2004 led New York State's Department of Environmental Conservation to issue violations for excessive air pollution and discharges of untreated sewage into the East River,[2] imposing a $75,000 fine and requiring major equipment upgrades.

NYOFCo's poor environmental performance and failure to maintain positive relations with the host community negatively impacted plans for expanding operations, mostly notably in Honolulu.[4] Given our company's growth strategy that calls for expanding existing services contracts and attracting new customers, shareholders are concerned that NYOFCo's environmental record and reputation may prevent or impair further growth.

We believe the report should include:

1. NYOFCo's total releases — both within its permit and emergency releases — to air, water and land, including releases of toxins, molds, pathogens, hazardous waste and hazardous air pollutants contained in the Environmental Protection Agency's 1998 proposed rules for national emission standards at Public Owned Treatment Works, and other environmental impacts in Hunts Point and the South Bronx;
2. The extent to which NYOFCo's operations may impact health and/or safety of individuals in Hunts Point and the South Bronx; and
3. How Synagro and NYOFCo integrate community environmental accountability into environmental management procedures and business practices.

We believe adoption of this proposal will benefit our company and its shareholders.

1. Williams, Sam. "Sludge and Scandal." The Gotham Gazette, 2/04.
2. Ragouzeous, Andrew. "CB 2 chairperson steps down after conflict of interest allegations." Bronx Times, 1/29/04.
3. McGurk, Joe. "Dung Flung in Bronx Silo Blast." New York Post, 9/5/03.
4. Guyette, Curt. "All mucked up." Metro Times Detroit, 2/25/04.

Ursuline Sisters of Tildonk
UNITED STATES PROVINCE
81-15 UTOPIA PARKWAY
JAMAICA, NEW YORK 11432-1308

PROVINCIAL'S OFFICE: (718) 591-0681
ASS'T PROVINCIAL'S OFFICE: (718) 969-6034
FAX: (718) 969-4275

December 20, 2005

Robert C. Boucher, President and CEO
Synagro Technologies, Inc.
1800 Bering Drive #1000
Houston, TX 77057

Dear Mr. Boucher:

On behalf of the Ursuline Sisters of Tildonk, U.S. Province, I am authorized to submit the following resolution which requests the Board of Directors to report to shareholders certain information on how our company ensures that it is accountable for NYOFCO's environmental impacts in the South Bronx, New York City community in which it operates, for inclusion in the proxy statement of the next annual meeting under Rule 14 a-8 of the General Rules and Regulations of the Securities Exchange Act of 1934. The Ursuline Sisters are cosponsoring this resolution with Mercy Investment Program, Sustainable South Bronx and other faith-based investors.

Our Sisters believe there must be an appropriate use and care of our natural resources of land and water. We also believe there must be attention to local communities where waste facilities are located. We know that solid wastes must be treated, preferably in the area where they are generated but we know, too, that this does not happen. Most frequently, the noxious facilities are located away from white, more wealthy neighborhoods. Until that attitude changes, we must ensure that such facilities operate with the best technology and architecture available. That is important to us as shareholders since at some point, the liabilities associated with health and environmental impacts of waste facilities may affect our Company.

The Ursuline Sisters of Tildonk, U.S. Province is the beneficial owner of 950 shares of Synagro stock. Verification of ownership follows. We plan to hold the stock at least until the time of the annual meeting and will be present in person or by proxy at that meeting.

~~Yours~~ truly,

Valerie Heinonen, o.s.u.

Valerie Heinonen, o.s.u.

Report on NYOFCo's Environmental Impacts

Resolved: shareholders request the Board of Directors to report, by January, 2007, at reasonable cost and omitting proprietary information, on environmental, health and safety impacts of New York Organic Fertilizer Company (NYOFCo), operated by Synagro, on the South Bronx, New York community.

Supporting statement

Corporations have a moral and legal responsibility to account for impacts—not only on ecosystems, but also on health and safety of communities hosting their facilities. Synagro operates NYOFCo pursuant to a New York City contract, our company's largest municipal services contract.

Hunts Point, NYOFCo's location, is a one square mile peninsula in southeastern Bronx County. It is one of the poorest Congressional Districts in the U.S., where incidence of childhood asthma is among the highest in the nation. This community bears heavy environmental burdens from local industrial and commercial facilities that daily bring thousands of diesel trucks through the neighborhood.

Since opening, NYOFCo has added to environmental burdens of Hunts Point and the surrounding area. Even after our company acquired NYOFCo operations in 2000, residents continued complaining that noxious odors emanate from the plant.[1,3] Odors from NYOFCo's smoke stacks, only 163 feet tall, are carried to nearby Public School 48 that sits on higher ground.

NYOFCo's safety record also causes alarm in the community and concern among shareholders due to a series of explosions and fires,[3] most recently in February 2005. Facility inspections and review of NYOFCo's stack tests in 2003-2004 led New York State's Department of Environmental Conservation to issue violations for excessive air pollution and discharges of untreated sewage into the East River,[2] imposing a $75,000 fine and requiring major equipment upgrades.

NYOFCo's poor environmental performance and failure to maintain positive relations with the host community negatively impacted plans for expanding operations, mostly notably in Honolulu.[4] Given our company's growth strategy that calls for expanding existing services contracts and attracting new customers, shareholders are concerned that NYOFCo's environmental record and reputation may prevent or impair further growth.

We believe the report should include:

1. NYOFCo's total releases — both within its permit and emergency releases — to air, water and land, including releases of toxins, molds, pathogens, hazardous waste and hazardous air pollutants contained in the Environmental Protection Agency's 1998 proposed rules for national emission standards at Public Owned Treatment Works, and other environmental impacts in Hunts Point and the South Bronx;
2. The extent to which NYOFCo's operations may impact health and/or safety of individuals in Hunts Point and the South Bronx; and
3. How Synagro and NYOFCo integrate community environmental accountability into environmental management procedures and business practices.

We believe adoption of this proposal will benefit our company and its shareholders.

1. Williams, Sam. "Sludge and Scandal." The Gotham Gazette, 2/04.
2. Ragouzeous, Andrew. "CB 2 chairperson steps down after conflict of interest allegations." Bronx Times, 1/29/04.
3. McGurk, Joe. "Dung Flung in Bronx Silo Blast." New York Post, 9/5/03.
4. Guyette, Curt. "All mucked up." Metro Times Detroit, 2/25/04.

SUSTAINABLE SOUTH BRONX

890 Garrison Ave. The Bronx, NY 10474
718.617.4668 Fax: 718.617.5228
www.ssbx.org

December 22, 2005

Robert C. Boucher, President and CEO
Synagro Technologies, Inc.
1800 Bering Drive #1000
Houston, TX 77057

Dear Mr. Boucher:

On behalf of Sustainable South Bronx, I am authorized to submit the following resolution which requests the Board of Directors to report to shareholders certain information on how our company ensures that it is accountable for the New York Organic Fertilizer Company's (NYOFCO) environmental impacts in the South Bronx, New York City, community in which it operates, for inclusion in the proxy statement of the next annual meeting under Rule 14 a-8 of the General Rules and Regulations of the Securities Exchange Act of 1934. Sustainable South Bronx is a sponsor of this resolution with Mercy Investment Program and other faith-based investors.

Sustainable South Bronx is a community-based organization that is dedicated to the implementation of sustainable development projects that are rooted in the needs of the community and the values of environmental justice. It is difficult to implement projects such as improving access to park space when facilities housed in the neighborhood repeatedly make the outdoor environment uninhabitable due to the odors and overall poor air quality resulting from their operations. The values of environmental justice affirm the right of all people to a safe and healthy work, home, and neighborhood space regardless of their socioeconomic status and the many ways by which it is determined, such as income, language, gender, race, age, citizenship, or sexual orientation. Furthermore, environmental justice ensures the right of people to participate as equal partners in the decisions that affect them.

The needs of our community, a predominantly African American and Latina/o neighborhood that forms part of the lowest income Congressional district in the nation, where one quarter of our children have been diagnosed with asthma and cancer rates exceed New York City's average, include assuring that the operations of and technology installed at the NYOFCo facility prevents harm to the people living close by. Your track record and responses to date have failed to assure us that you are operating in a manner that takes in to account or protects the people of the South Bronx, the river or the land surrounding the NYOFCo location. We remain open to meeting with you to discuss the concerns raised in our resolution.

Sustainable South Bronx is the beneficial owner of 50 shares of Synagro stock. Verification of ownership follows. We plan to hold the stock at least until the time of the annual meeting and will be present in person or by proxy at that meeting.

Sincerely,

Elena Conte
Solid Waste and Energy Coordinator

Report on NYOFCo's Environmental Impacts

Resolved: shareholders request the Board of Directors to report, by January, 2007, at reasonable cost and omitting proprietary information, on environmental, health and safety impacts of New York Organic Fertilizer Company (NYOFCo), operated by Synagro, on the South Bronx, New York community.

Supporting statement

Corporations have a moral and legal responsibility to account for impacts—not only on ecosystems, but also on health and safety of communities hosting their facilities. Synagro operates NYOFCo pursuant to a New York City contract, our company's largest municipal services contract.

Hunts Point, NYOFCo's location, is a one square mile peninsula in southeastern Bronx County. It is one of the poorest Congressional Districts in the U.S., where incidence of childhood asthma is among the highest in the nation. This community bears heavy environmental burdens from local industrial and commercial facilities that daily bring thousands of diesel trucks through the neighborhood.

Since opening, NYOFCo has added to environmental burdens of Hunts Point and the surrounding area. Even after our company acquired NYOFCo operations in 2000, residents continued complaining that noxious odors emanate from the plant.[1, 3] Odors from NYOFCo's smoke stacks, only 163 feet tall, are carried to nearby Public School 48 that sits on higher ground.

NYOFCo's safety record also causes alarm in the community and concern among shareholders due to a series of explosions and fires,[3] most recently in February 2005. Facility inspections and review of NYOFCo's stack tests in 2003-2004 led New York State's Department of Environmental Conservation to issue violations for excessive air pollution and discharges of untreated sewage into the East River,[2] imposing a $75,000 fine and requiring major equipment upgrades.

NYOFCo's poor environmental performance and failure to maintain positive relations with the host community negatively impacted plans for expanding operations, mostly notably in Honolulu.[4] Given our company's growth strategy that calls for expanding existing services contracts and attracting new customers, shareholders are concerned that NYOFCo's environmental record and reputation may prevent or impair further growth.

We believe the report should include:

1. NYOFCo's total releases — both within its permit and emergency releases — to air, water and land, including releases of toxins, molds, pathogens, hazardous waste and hazardous air pollutants contained in the Environmental Protection Agency's 1998 proposed rules for national emission standards at Public Owned Treatment Works, and other environmental impacts in Hunts Point and the South Bronx;
2. The extent to which NYOFCo's operations may impact health and/or safety of individuals in Hunts Point and the South Bronx; and
3. How Synagro and NYOFCo integrate community environmental accountability into environmental management procedures and business practices.

We believe adoption of this proposal will benefit our company and its shareholders.

1. Williams, Sam. "Sludge and Scandal." The Gotham Gazette, 2/04.
2. Ragouzeous, Andrew. "CB 2 chairperson steps down after conflict of interest allegations." Bronx Times, 1/29/04.
3. McGurk, Joe. "Dung Flung in Bronx Silo Blast." New York Post, 9/5/03.
4. Guyette, Curt. "All mucked up." Metro Times Detroit, 2/25/04.

Exhibit B

See attached.

				Literature Research regarding pathogen, molds and bioaerosols from operations similar to NYOFCo	item 38.1	One time report	Dec-02
				Stack Test	item 1-32	Jan. 22, 2006	Triennial
				AGC, air guides to protect public health and evironment	item 1-32	30 days after submittal of stack test results	after every compliance stack test
				Odor complaint summary	Item 49.2	1st and 15th of every month	length of permit
				Emissions Inventory, operational data	Clean Air Act	Annual	every April 15th
NYC DEP IDP	03-P2830-1	Industrial Discharge Permit	3-Jun-08	Analytical Data	Section C.1	30-Jun	December 1 - May 31
						31-Dec	June 1 - November 30
360, Solid Waste Permit	2-6007-00140/00001-9	Solid Waste	20-Jan-05	Analytical Data		30 days after end of quarter	Quarterly
				Analytical Data		60 days after end of year	Annually
				Informational of Process Modifications		Per Occurrence	Per Occurrence
				Engineering Report and O&M manuals		Per renewal	Quinquennial
NYS DEC	N/A	Remediation	N/A	Analytical Data		Per Occurrence	Until remediation site is closed out
DEP Residuals Depart				Informational Operational summary of contract performance	Not applicable	21st of month	monthly
DEP Right-to-Know	N/A	Annual reporting	N/A	Inventory of chemicals used on-site	Not applicable	March 1st	Annually
Clean Water Act	N/A	Every 5 years	Feb-09	Spill Prevention, Control and Countermeasures Plan Reportable Spills	Not applicable Not applicable	Feb-04 Per Occurrence	Quinquennial Per Occurrence
Clean Water Act	N/A	Every 5 years	Sep-09	Chemical storage tank integrity test	Not applicable	Sep-04	Quinquennial
Clean Water Act	N/A	Every 10 years	Sep-14	Petroleum storage tank integrity test	Not applicable	Sep-04	Decennial

Permit Title	Permit Number	Permit Description	Permit Expiration Date	Report Type	Permit Section	Report Due Date	Report Period
Title V	2-6007-00140/00011	Allow NYOFCo to discharge combustion gases in to air.	29-Aug-07	Informational of Process Modifications	Item 4-2	Per Occurrence	Per Occurrence
				6-mos Compliance Certification	item 25.2	30 days after end of period	7/1/XX - 12/31/XX
				6-mos Compliance Certification	item 25.2	30 days after end of period	1/01/XX - 6/30/XX
				Annual Compliance Certification	item 26	30 days after end of period	6/30/XX - 6/30/XX
				6 minute average	item 31.2	Upon request	Per Occurrence
				quarterly Opacity and CGA audits, includes Opacity emissions	item 34.2	30 days after end of period	1st q
				quarterly Opacity and CGA audits, includes Opacity emissions	item 34.2	30 days after end of period	2nd q
				quarterly Opacity and CGA audits, includes Opacity emissions	item 34.2	30 days after end of period	3rd q
				quarterly Opacity and CGA audits, includes Opacity emissions	item 34.2	30 days after end of period	4th q
				Annual RATA for emissions monitoring, (accuracy test of equip)	item 34.2	30 days after end of period	Annual
				kero use, 6-mos report	item 37.2	30 days after end of period	7/1/XX - 12/31/XX
				kero use, 6-mos report		30 days after end of period	1/01/XX - 6/30/XX
				emergency	item6.1	w/in 24 hours after event	length of permit
				emergency	item 43.1	w/in 24 hours after awareness not to exceed 48 hrs.	length of permit
				written report	item 43.1	w/in 30 days after event	length of permit
				written report	item 49.2	1st and 15th	length of permit

Exhibit C

See attached.

NYOFCO PELLETIZING FACILITY

COMPLIANCE WITH THE DAR-1 AMBIENT GUIDLINE CONCENTRATION LIMITS

Prepared for Synagro

Prepared by:

Ned Ostojic, Ph.D.,P.E.

February 23, 2004

OS&E Project No. 1339-M-00

O S&E

Odor Science & Engineering, Inc.

www.odorscience.com

1350 Blue Hills Avenue, Bloomfield, CT 06002

(860) 243-9380 Fax: (860) 243-9431

SUMMARY

The results from 2002 – 2003 compliance air emissions testing at NYOFCO were used as input to the ISCST3 atmospheric dispersion model to determine NYOFCO's compliance with the New York State's ambient concentration limits – Annual Guideline Concentrations (AGCs) and the one hour Short-term Guideline Concentrations (SGCs). A polar receptor grid with 1,080 receptors arranged in 36 rows at 10 degree intervals, with the origin at the NYOFCO stack, was used. In addition, three discrete receptors were located at the schools PS 48, PS 62 and MS 201. A five year meteorological data set from La Guardia airport was used in the modeling. The highest predicted annual and one hour impacts at all locations were found to be substantially below the corresponding AGC and SGC limits for all reported compounds.

Odor Science & Engineering, Inc. 1350 Blue Hills Avenue Bloomfield, CT 06002
Phone: (860) 243-9380 Fax: (860) 243-9431 www.odorscience.com

TABLE OF CONTENTS

Odor Science & Engineering, Inc. 1350 Blue Hills Avenue Bloomfield, CT 06002
Phone: (860) 243-9380 Fax: (860) 243-9431 www.odorscience.com

1.0 INTRODUCTION

The New York Organic Fertilizer Company (NYOFCO) operates six biosolids pelletizer trains at its facility in the Bronx, New York. Atmospheric emissions from the pelletizers are controlled by multi-stage control systems with regenerative thermal oxidizers (RTOs) as the final stage. As part of the operating permit, NYOFCO was required by the New York State Department of Environmental Conservation (DEC) to conduct an air emissions compliance test program. The program was conducted in December of 2002 and in January of 2003 by Eastmount Environmental Services, LLC. The results are presented in the April 2003 report by Eastmount Environmental.

The DEC has developed ambient concentration limits for a number of compounds emitted into atmosphere from industrial facilities. The limits have been developed for both long term and short term exposure: Annual Guideline Concentrations (AGCs) and the one hour Short-term Guideline Concentrations (SGCs). Compliance with these limits was determined by atmospheric dispersion modeling, using the ISCST3 model recommended by the US EPA. Model set-up and the results of the modeling are presented below.

Odor Science & Engineering, Inc. 1350 Blue Hills Avenue Bloomfield, CT 06002
Phone: (860) 243-9380 Fax: (860) 243-9431 www.odorscience.com

2.0 DISPERSION MODEL SET-UP

The EPA recommended model, ISCST3, was used with a 5-year set of meteorological data for years 1991 through 1995, from New York City's LaGuardia Airport located in proximity to NYOFCO.

The modeling was conducting with several conservative assumptions to assure that the predicted impacts are indeed the highest under any conditions. These assumptions include:

1. All six RTOs were assumed to be in operation for both the annual and one hour impacts modeling, even though NYOFCO rarely operates more than three drier trains;
2. The emissions for some compounds were reported at "less then the detection limit of the method". For the purpose of the impact analysis the emissions for those compounds were assumed to be equal to the detection limits even though the actual concentrations could have been many times lower, if the compounds were present at all.
3. The emissions for particulate matter less than 10 um and less than 2.5 um in size (PM-10) and PM-2.5 respectively) were assumed to be the same as total particulate even though, by definition, these emissions represent only a fraction of total particulate emitted.

Residual emissions from the six RTOs are discharged through individual flues contained in a concrete stack. In practice these individual exhausts form a single plume and consequently modeling was performed using a single source.

For the purpose of modeling, the plume flow rate and temperature were determined as the average of the measured flow rates and temperatures of individual tested RTO exhausts:

	ACFM	° F
train 1	48,270	388
train 2	46,506	395
train 3	48,524	449
train 4	45,695	423
train 5	50,970	425
train 6	45,487	365
TOTAL/AVERAGE	285,452	407.5

The source model input parameters are listed below:

stack height	49.68 m (163 ft)
stack diameter [a]	2.61 m
stack exit velocity [b]	25.13 m/sec (285,452 ACFM)
exhaust temperature [c]	481.8 ° K (407.5 ° F)

Odor Science & Engineering, Inc. 1350 Blue Hills Avenue Bloomfield, CT 06002
Phone: (860) 243-9380 Fax: (860) 243-9431 www.odorscience.com

a) calculated from a combined cross sectional areas of six flues, each 3.5 ft in diameter
b) based on combined average flow rates measured at all six flues
c) average of the reported average values measured at all six flues

Modeling was performed with a polar grid of 1,080 receptors placed in rows at 10 degree intervals, with NYOFCO stack at the origin of the grid. In each row the receptors were placed at 100 meter intervals out to a distance of 1 km and at 200 meter intervals at distances beyond 1 km out to 5 km. Modeling for the grid receptors was performed with the "flat terrain" option. In addition, the three public schools in the area: PS48, PS62 and MS201 were modeled as discrete receptors. Actual terrain elevations were used for these receptors. These receptors were further elevated using the "flagpole" option, to account for potentially elevated receptors:

school	coordinates (UTM)		Terrain elevation	"flagpole" elevation
	East	North		
PS 48	593840.00	4518510.00	21.3 m (70 ft)	9.1 m (30 ft)
PS 62	592700.00	4518440.00	12.1 m (40 ft)	9.1 m (30 ft)
MS 201	593950.00	4518600.00	18.3 m (60 ft)	6.1 m (20 ft)

Modeling was performed with a nominal emission rate of 1 gram/second. To determine the highest predicted impact for each compound, the highest impact predicted with the 1 gram/second emission rate was multiplied by the actual emission rate for that compound.

Emission rates for the compounds reported in the 2002 – 2003 tests are presented in Table 2-1. An average of triplicate measurements was reported for each compound at each pelletizer train. In addition, the table provides the average and the maximum of the reported emission rates for each compound. The average value was used in modeling of annual impacts for determining compliance with the AGCs. The maximum values were used for determining compliance with the one-hour SGC limits. Table 2-1 shows the average and maximum emissions values for six trains operating simultaneously. Emissions from simultaneous operation of six trains were used for the purpose of dispersion modeling, even though more than three trains are seldom operated simultaneously.

Figure 2-2 shows the NYOFCO site boundary and significant structures on site.

Odor Science & Engineering, Inc. 1350 Blue Hills Avenue Bloomfield, CT 06002
Phone: (860) 243-9380 Fax: (860) 243-9431 www.odorscience.com

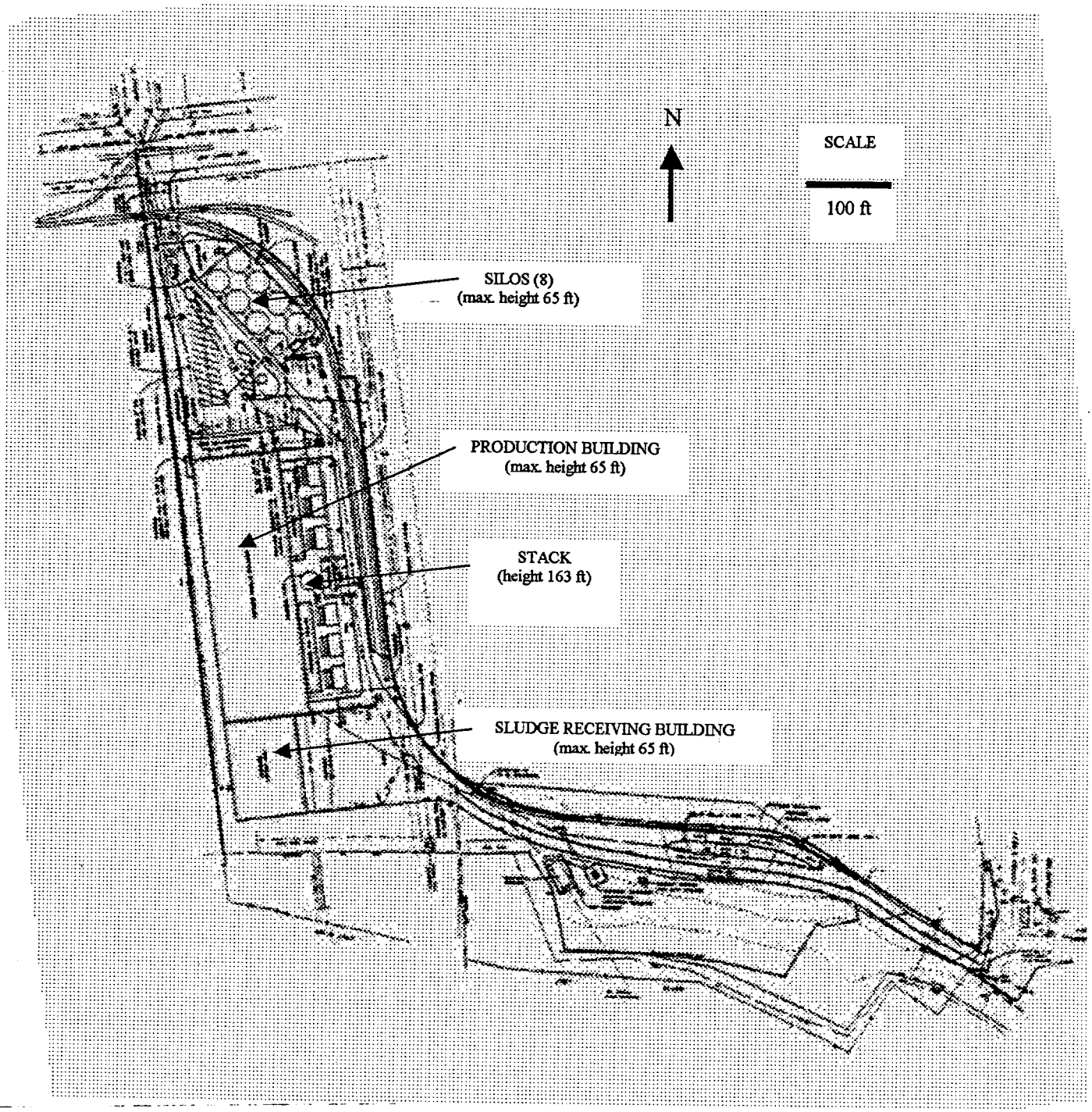


Figure 2-2. NYOFCO Site diagram

3.0 RESULTS

The results of the analysis are shown in Tables 3-1 through 3-4. Tables 3-1 and 3-2 show peak annual impacts for the grid receptors and the discrete receptors respectively. Likewise, Tables 3-3 and 3-4 show peak one hour impacts for the grid and the discrete receptors.

The highest predicted annual impact at any of the grid receptors, obtained with a 1 g/sec emission rate, was 0.19616 ug/m^3. This value was used to calculate specific highest impacts for the individual compounds. For example, the impact of 7.87 x 10^{-6} ug/m^3 for hexavalent chromium, shown in Table 3-1, was calculated using the average emission rate of 3.18 x 10^{-4} lb/hr for hexavalent chromium (based on simultaneous operation of six drier trains), as follows:

1) (3.18 x 10^{-4} lb/hr x 453.6 g/lb) / 3,600 sec/hr = 4.01 x 10^{-5} g/sec

2) (4.10 x 10^{-5} g/sec / 1 g/sec) x 0.19616 ug/m^3 = 7.87 x 10^{-6} ug/m^3

The table also shows the highest predicted annual impact for each compound as a fraction of the corresponding AGC. The values in the table are sorted by those fractions in a descending order. As seen in the table, the compound with the highest impact relative to the AGC was hexavalent chromium. The highest predicted impact for that compound amounts to only 0.0948 of the AGC. All other compounds represent even lower fractions of their AGCs, ranging from 0.0236 to 1.02 x 10^{-6}.

The highest annual impacts predicted for the three sensitive receptors – schools PS 48, PS 62 and MS 201 – are presented in Table 3-2. These impacts were calculated as shown above, using the average emission rate for each compound based on 6 trains operating simultaneously and the maximum impacts predicted at each school with a 1 g/sec emission rate. The highest impacts at all three schools are lower than the highest impact predicted for the grid receptors. The highest impacts relative to the AGC were again predicted for hexavalent chromium, ranging from 0.00969 to 0.0324 of the AGC at PS 62 and at PS 48, respectively.

Tables 3-3 and 3-4 are analogous to Tables 3-1 and 3-2, with the difference being that the impacts shown in those tables are maximum predicted 1-hour averages and are thus compared with the SGC values. As seen in Tables 3-3 and 3-4, the highest predicted 1-hour impacts are even further below their respective ambient limits than the annual impacts. For example, in Table 3-3 the highest 1-hour impact at any receptor, based on maximum emissions at any of the trains was, predicted for PM-2.5. That impact represents 0.0112 of the corresponding SGC. Likewise, in Table 3-4, the highest impact, predicted for PM-2.5 at PS 48 (the highest of the three schools), represents 0.00475 of the corresponding SGC.

Odor Science & Engineering, Inc. 1350 Blue Hills Avenue Bloomfield, CT 06002
Phone: (860) 243-9380 Fax: (860) 243-9431 www.odorscience.com

Table 3-1. Highest predicted impacts as fractions of the AGCs (grid receptors)

compound	CAS number	AGC (ug/m3)		average stack emissions - 6 trains (lb/hr)	peak impact (ug/m3)	peak impact as fraction of AGC
hex chromium	18540-29-9	8.30E-05		3.18E-04	7.87E-06	9.48E-02
total PAH	--	2.00E-02		1.91E-02	4.72E-04	2.36E-02
nitrogen oxide	10102-43-9	74		2.29E+01	5.67E-01	7.66E-03
nickel	07440-02-0	4.00E-03		8.17E-04	2.02E-05	5.05E-03
particulate PM-2.5	NY075-02-5	15		1.40E+00	3.47E-02	2.31E-03
sulfur dioxide	07446-09-5	8.00E+01		5.00E+00	1.24E-01	1.54E-03
hydrogen sulfide	07783-06-4	1.00E+00	<	4.32E-02	1.07E-03	1.07E-03
phenanthrene	00085-01-8	2.00E-02		8.56E-04	2.12E-05	1.06E-03
particulate	NY075-00-0	50		1.40E+00	3.47E-02	6.94E-04
particulate PM-10	NY074-00-5	50		1.40E+00	3.47E-02	6.94E-04
ammonia	07664-41-7	1.00E+02		1.85E+00	4.56E-02	4.56E-04
anthracene	00120-12-7	2.00E-02		1.44E-04	3.55E-06	1.78E-04
pyrene	00129-00-0	2.00E-02		1.10E-04	2.72E-06	1.36E-04
benzo(a)pyrene	50-32-8	2.00E-03		7.17E-06	1.77E-07	8.86E-05
HCl	07647-01-0	20	<	3.66E-02	9.05E-04	4.52E-05
naphthalene	00091-20-3	3		5.13E-03	1.27E-04	4.23E-05
chrysene	00218-01-9	2.00E-02		2.00E-05	4.95E-07	2.48E-05
mercury	07439-97-6	3.00E-01		2.89E-04	7.15E-06	2.38E-05
di-n-octyl phthalate	00117-81-7	4.20E-01		3.73E-04	9.21E-06	2.19E-05
chromium	07440-47-3	1.20E+00		9.00E-04	2.22E-05	1.85E-05
benz(a)anthracene	00056-55-3	2.00E-02		1.34E-05	3.31E-07	1.65E-05
lead	07439-92-1	7.50E-01		3.91E-04	9.66E-06	1.29E-05
dibenzo(a,h)anthracene	00053-70-3	2.00E-02		7.68E-06	1.90E-07	9.49E-06
carbon disulfide	00075-15-0	7.00E+02	<	9.64E-02	2.38E-03	3.40E-06
fluorene	07782-41-4	4.00E-01		4.98E-05	1.23E-06	3.08E-06
di-n-butyl-phthalate	00084-74-2	12		4.97E-04	1.23E-05	1.02E-06
2-methylnaphthalene	91-57-6	--		7.65E-03	1.89E-04	--
acenaphthalene	208-96-8	--		7.17E-06	1.77E-07	--
acenaphthene	83-32-9	--		8.42E-03	2.08E-04	--
benzo(b)fluoranthene	205-99-2	--		1.61E-05	3.97E-07	--
benzo(e)pyrene	192-97-2	--		1.43E-05	3.54E-07	--
benzo(g,h,l)perylene	191-24-2	--		1.96E-05	4.84E-07	--
benzo(k)fluoranthene	207-08-9	--		1.17E-05	2.90E-07	--
bis(2-ethyhexyl)phthalate	117-81-7	--		2.82E-03	6.96E-05	--
fluoranthene	206-44-0	--		9.59E-05	2.37E-06	--
indeno(1,2,3-c,d)pyrene	193-39-5	--		7.84E-06	1.94E-07	--
perylene	198-55-0	--		1.17E-05	2.90E-07	--
carbon monoxide	00630-08-0	--		4.27E+00	1.06E-01	--

Note: Average stack emissions are for six drier trains operating simultaneously. In reality the facility seldom operates more than three trains simultaneously

Table 3-2. Peak predicted annual impacts at sensitive receptors as fractions of the AGCs

compound	CAS number	AGC (ug/m3)	average emissions 6 trains (lbs/hr)	peak impact as a fraction of AGC		
				PS 48	PS 62	MS 201
hex chromium	18540-29-9	8.30E-05	3.18E-04	3.24E-02	9.69E-03	2.88E-02
total PAH	--	2.00E-02	1.91E-02	8.06E-03	2.41E-03	7.17E-03
nitrogen oxide	10102-43-9	74	2.29E+01	2.61E-03	7.82E-04	2.33E-03
nickel	07440-02-0	4.00E-03	8.17E-04	1.72E-03	5.15E-04	1.53E-03
particulate PM-2.5	NY075-02-5	15	1.40E+00	7.90E-04	2.36E-04	7.03E-04
sulfur dioxide	07446-09-5	8.00E+01	5.00E+00	5.27E-04	1.58E-04	4.69E-04
hydrogen sulfide	07783-06-4	1.00E+00	< 4.32E-02	3.65E-04	1.09E-04	3.25E-04
phenanthrene	00085-01-8	2.00E-02	8.56E-04	3.61E-04	1.08E-04	3.21E-04
particulate	NY075-00-0	50	1.40E+00	2.37E-04	7.09E-05	2.11E-04
particulate PM-10	NY074-00-5	50	1.40E+00	2.37E-04	7.09E-05	2.11E-04
ammonia	07664-41-7	1.00E+02	1.85E+00	1.56E-04	4.66E-05	1.39E-04
anthracene	00120-12-7	2.00E-02	1.44E-04	6.06E-05	1.81E-05	5.39E-05
pyrene	00129-00-0	2.00E-02	1.10E-04	4.64E-05	1.39E-05	4.13E-05
HCl	07647-01-0	20	< 3.66E-02	1.54E-05	4.62E-06	1.37E-05
naphthalene	00091-20-3	3	5.13E-03	1.44E-05	4.32E-06	1.28E-05
chrysene	00218-01-9	2.00E-02	2.00E-05	8.45E-06	2.53E-06	7.52E-06
mercury	07439-97-6	3.00E-01	2.89E-04	8.14E-06	2.44E-06	7.24E-06
di-n-octyl phthalate	00117-81-7	4.20E-01	3.73E-04	7.48E-06	2.24E-06	6.66E-06
chromium	07440-47-3	1.20E+00	9.00E-04	6.33E-06	1.89E-06	5.63E-06
benz(a)anthracene	00056-55-3	2.00E-02	1.34E-05	5.65E-06	1.69E-06	5.03E-06
lead	07439-92-1	7.50E-01	3.91E-04	4.40E-06	1.32E-06	3.91E-06
dibenzo(a,h)anthracene	00053-70-3	2.00E-02	7.68E-06	3.24E-06	9.70E-07	2.88E-06
carbon disulfide	00075-15-0	7.00E+02	< 9.64E-02	1.16E-06	3.48E-07	1.03E-06
fluorene	07782-41-4	4.00E-01	4.98E-05	1.05E-06	3.14E-07	9.35E-07
di-n-butyl-phthalate	00084-74-2	12	4.97E-04	3.49E-07	1.04E-07	3.11E-07
2-methylnaphthalene	91-57-6	--	7.65E-03	--	--	--
acenaphthalene	208-96-8	--	7.17E-06	--	--	--
acenaphthene	83-32-9	--	8.42E-03	--	--	--
benzo(b)fluoranthene	205-99-2	--	1.61E-05	--	--	--
benzo(e)pyrene	192-97-2	--	1.43E-05	--	--	--
benzo(g,h,l)perylene	191-24-2	--	1.96E-05	--	--	--
benzo(k)fluoranthene	207-08-9	--	1.17E-05	--	--	--
bis(2-ethyhexyl)phthalate	117-81-7	--	2.82E-03	--	--	--
fluoranthene	206-44-0	--	9.59E-05	--	--	--
indeno(1,2,3-c,d)pyrene	193-39-5	--	7.84E-06	--	--	--
perylene	198-55-0	--	1.17E-05	--	--	--
carbon monoxide	00630-08-0	--	4.27E+00	--	--	--

Note: Average stack emissions are for six drier trains operating simultaneously. In reality the facility seldom operates more than three trains simultaneously

Table 3-3. Highest predicted one hour impacts as fractions of the SGCs (grid receptors)

compound	CAS number	maximum emissions (lb/hr)	peak impact (ug/m3)	SGC (ug/m3)	peak impact / SGC
particulate PM-2.5	NY075-00-5	2.86E+00	1.80E+00	160	1.12E-02
sulfur dioxide	07446-09-5	7.44E+00	4.67E+00	9.10E+02	5.14E-03
particulate	NY075-00-0	2.86E+00	1.80E+00	380	4.73E-03
particulate PM-10	NY074-00-5	2.86E+00	1.80E+00	380	4.73E-03
hydrogen sulfide	07783-06-4	< 4.76E-02	2.99E-02	14	2.14E-03
ammonia	07664-41-7	4.55E+00	2.86E+00	2.40E+03	1.19E-03
HCl	07647-01-0	< 1.36E-01	8.56E-02	150	5.70E-04
carbon monoxide	00630-08-0	5.22E+00	3.28E+00	1.40E+04	2.34E-04
nickel	07440-02-0	1.36E-03	8.52E-04	6.00E+00	1.42E-04
mercury	07439-97-6	3.65E-04	2.30E-04	1.80E+00	1.28E-04
fluorene (fluorine ?)	07782-41-4	2.63E-04	1.65E-04	7.1	2.32E-05
carbon disulfide	00075-15-0	< 1.06E-01	6.67E-02	6200	1.08E-05
naphthalene	00091-20-3	8.04E-03	5.05E-03	7900	6.39E-07
hex chromium	18540-29-9	4.99E-04	3.13E-04	--	--
nitrogen oxide	10102-43-9	2.50E+01	1.57E+01	--	--
phenanthrene	00085-01-8	1.36E-03	8.52E-04	--	--
anthracene	00120-12-7	2.26E-04	1.42E-04	--	--
pyrene	00129-00-0	1.90E-04	1.19E-04	--	--
chrysene	00218-01-9	4.29E-05	2.69E-05	--	--
di-n-octyl phthalate	00117-81-7	3.83E-04	2.40E-04	--	--
chromium	07440-47-3	1.65E-03	1.04E-03	--	--
benz(a)anthracene	00056-55-3	2.62E-05	1.64E-05	--	--
lead	07439-92-1	5.51E-04	3.46E-04	--	--
dibenzo(a,h)anthracene	00053-70-3	1.01E-05	6.37E-06	--	--
di-n-butyl-phthalate	00084-74-2	7.20E-04	4.52E-04	--	--
2-methylnaphthalene	91-57-6	1.23E-02	7.73E-03	--	--
acenaphthalene	208-96-8	7.38E-06	4.64E-06	--	--
acenaphthene	83-32-9	4.85E-02	3.05E-02	--	--
benzo(a)pyrene	50-32-8	7.38E-06	4.64E-06	--	--
benzo(b)fluoranthene	205-99-2	3.39E-05	2.13E-05	--	--
benzo(e)pyrene	192-97-2	1.47E-05	9.23E-06	--	--
benzo(g,h,l)perylene	191-24-2	3.97E-05	2.49E-05	--	--
benzo(k)fluoranthene	207-08-9	2.00E-05	1.26E-05	--	--
bis(2-ethyhexyl)phthalate	117-81-7	4.39E-03	2.76E-03	--	--
fluoranthene	206-44-0	1.74E-04	1.09E-04	--	--
indeno(1,2,3-c,d)pyrene	193-39-5	1.11E-05	6.97E-06	--	--
perylene	198-55-0	1.47E-05	9.23E-06	--	--

Note: Maximum stack emissions assume simultaneous operation of six drier trains with the highest emission levels measured at any train. In reality the facility seldom operates more than three trains simultaneously

Table 3-4. Highest predicted one hour impacts as fractions of the SGCs (discrete sensitive receptors)

compound	CAS number	maximum emissions (lb/hr)	SGC (ug/m3)	peak impact as a fraction of SGC		
				PS 48	PS 62	MS 201
particulate PM-2.5	NY075-00-5	2.86E+00	160	4.75E-03	4.51E-03	4.52E-03
sulfur dioxide	07446-09-5	7.44E+00	9.10E+02	2.17E-03	2.06E-03	2.07E-03
particulate	NY075-00-0	2.86E+00	380	2.00E-03	1.90E-03	1.90E-03
particulate PM-10	NY074-00-5	2.86E+00	380	2.00E-03	1.90E-03	1.90E-03
hydrogen sulfide	07783-06-4	< 4.76E-02	14	9.04E-04	8.58E-04	8.60E-04
ammonia	07664-41-7	4.55E+00	2.40E+03	5.04E-04	4.78E-04	4.79E-04
HCl	07647-01-0	< 1.36E-01	150	2.41E-04	2.29E-04	2.29E-04
carbon monoxide	00630-08-0	5.22E+00	1.40E+04	9.90E-05	9.40E-05	9.42E-05
nickel	07440-02-0	1.36E-03	6.00E+00	6.00E-05	5.70E-05	5.71E-05
mercury	07439-97-6	3.65E-04	1.80E+00	5.39E-05	5.12E-05	5.13E-05
fluorene (fluorine ?)	07782-41-4	2.63E-04	7.1	9.83E-06	9.33E-06	9.35E-06
carbon disulfide	00075-15-0	< 1.06E-01	6200	4.55E-06	4.32E-06	4.33E-06
naphthalene	00091-20-3	8.04E-03	7900	2.70E-07	2.57E-07	2.57E-07
hex chromium	18540-29-9	4.99E-04	--	--	--	--
nitrogen oxide	10102-43-9	2.50E+01	--	--	--	--
phenanthrene	00085-01-8	1.36E-03	--	--	--	--
anthracene	00120-12-7	2.26E-04	--	--	--	--
pyrene	00129-00-0	1.90E-04	--	--	--	--
chrysene	00218-01-9	4.29E-05	--	--	--	--
di-n-octyl phthalate	00117-81-7	3.83E-04	--	--	--	--
chromium	07440-47-3	1.65E-03	--	--	--	--
benz(a)anthracene	00056-55-3	2.62E-05	--	--	--	--
lead	07439-92-1	5.51E-04	--	--	--	--
dibenzo(a,h)anthracene	00053-70-3	1.01E-05	--	--	--	--
di-n-butyl-phthalate	00084-74-2	7.20E-04	--	--	--	--
2-methylnaphthalene	91-57-6	1.23E-02	--	--	--	--
acenaphthalene	208-96-8	7.38E-06	--	--	--	--
acenaphthene	83-32-9	4.85E-02	--	--	--	--
benzo(a)pyrene	50-32-8	7.38E-06	--	--	--	--
benzo(b)fluoranthene	205-99-2	3.39E-05	--	--	--	--
benzo(e)pyrene	192-97-2	1.47E-05	--	--	--	--
benzo(g,h,i)perylene	191-24-2	3.97E-05	--	--	--	--
benzo(k)fluoranthene	207-08-9	2.00E-05	--	--	--	--
bis(2-ethyhexyl)phthalate	117-81-7	4.39E-03	--	--	--	--
fluoranthene	206-44-0	1.74E-04	--	--	--	--
indeno(1,2,3-c,d)pyrene	193-39-5	1.11E-05	--	--	--	--
perylene	198-55-0	1.47E-05	--	--	--	--

Note: Maximum stack emissions assume simultaneous operation of six drier trains with the highest emission levels measured at any train. In reality the facility seldom operates with more than three trains simultaneously

APPENDIX

SELECTED MODEL INPUT AND OUTPUT DATA

APPENDIX: MODEL SOURCE INPUT (DISCRETE RECEPTORS)

```
CO STARTING
CO TITLEONE NYOFCO
CO TITLETWO GENERIC EMISSIONS - DISCREET RECEPTORS
CO MODELOPT CONC URBAN GRDRIS
CO AVERTIME 1 ANNUAL
CO POLLUTID GENERIC
CO TERRHGTS ELEV
CO FLAGPOLE
CO RUNORNOT RUN
CO ERRORFIL NYOFCOb.ERR
CO FINISHED

SO STARTING
SO ELEVUNIT FEET
SO LOCATION NYOFCO  POINT 593340.  4517770.  10.
SO SRCPARAM NYOFCO  1.00  49.68  481.8   25.13  2.61
SO BUILDHGT NYOFCO  19.81   19.81   19.81   19.81   19.81   19.81
SO BUILDHGT NYOFCO  19.81   19.81   19.81   19.81   19.81   19.81
SO BUILDHGT NYOFCO  19.81   19.81   19.81   19.81   19.81   19.81
SO BUILDHGT NYOFCO  19.81   19.81   19.81   19.81   19.81   19.81
SO BUILDHGT NYOFCO  19.81   19.81   19.81   19.81   19.81   19.81
SO BUILDHGT NYOFCO  19.81   19.81   19.81   19.81   19.81   19.81
SO BUILDWID NYOFCO  51.19   70.34   87.36  101.72  112.99  120.83
SO BUILDWID NYOFCO  124.99  125.36  121.92  125.36  124.99  120.83
SO BUILDWID NYOFCO  112.99  101.72   87.36   70.34   51.19   30.48
SO BUILDWID NYOFCO  51.19   70.34   87.36  101.72  112.99  120.83
SO BUILDWID NYOFCO  124.99  125.36  121.92  125.36  124.99  120.83
SO BUILDWID NYOFCO  112.99  101.72   87.36   70.34   51.19   30.48
SO SRCGROUP ALL
SO FINISHED

RE STARTING
RE ELEVUNIT FEET
RE DISCCART 593840.  4518510.  70.  9.14
RE DISCCART 592700.  4518440.  40.  9.14
RE DISCCART 593950.  4518600.  60.  6.10
RE FINISHED

ME STARTING
ME INPUTFIL LGA9195M.ASC
ME ANEMHGHT 6.100  METERS
ME SURFDATA 14732  1991  LaGuardia
ME UAIRDATA 93755  1991  Atlantic City
ME FINISHED

OU STARTING
OU RECTABLE  ALLAVE  FIRST
OU MAXTABLE  ALLAVE  10
OU FINISHED


 *** Message Summary For ISC3 Model Setup ***
```

APPENDIX: BPIP MODEL INPUT FILE

```
'Hunts Point Building Profile Analysis - NYOFCO'
'ST'
'FEET' 0.3048
'UTMN' 0.0
1
'NYOFCO'       1        12
        4        65
                 -420      571
                 -520      571
                 -520      971
                 -420      971
1
'NYOFCO' 12    163    -407     771
```

Odor Science & Engineering, Inc. 1350 Blue Hills Avenue Bloomfield, CT 06002
Phone: (860) 243-9380 Fax: (860) 243-9431 www.odorscience.com

APPENDIX: BPIP MODEL OUTPUT FILE

BPIP (Dated: 95086)
DATE : 5/26/ 0
TIME : 15: 6:45
Hunts Point Building Profile Analysis - NYOFCO

==========
BPIP PROCESSING INFORMATION:
==========

The ST flag has been set for processing for an ISCST2 run.

Inputs entered in FEET will be converted to meters using a conversion factor of .3048. Output will be in meters.

UTMP is set to UTMN. The input is assumed to be in a local X-Y coordinate system as opposed to a UTM coordinate system. True North is in the positive Y direction.

Plant north is set to .00 degrees with respect to True North.

Hunts Point Building Profile Analysis - NYOFCO

PRELIMINARY* GEP STACK HEIGHT RESULTS TABLE
(Output Units: meters)

Stack Name	Stack Height	Stack-Building Base Elevation Differences	GEP** EQN1	Preliminary* GEP Stack Height Value
NYOFCO	49.68	.00	49.53	65.00

* Results are based on Determinants 1 & 2 on pages 1 & 2 of the GEP Technical Support Document. Determinant 3 may be investigated for additional stack height credit. Final values result after Determinant 3 has been taken into consideration.

** Results were derived from Equation 1 on page 6 of GEP Technical Support Document. Values have been adjusted for any stack-building base elevation differences.

Note: Criteria for determining stack heights for modeling emission limitations for a source can be found in Table 3.1 of the GEP Technical Support Document.

BPIP (Dated: 95086)
DATE : 5/26/ 0
TIME : 15: 6:45

Hunts Point Building Profile Analysis - NYOFCO

BPIP output is in meters

SO	BUILDHGT	NYOFCO	19.81	19.81	19.81	19.81	19.81	19.81
SO	BUILDHGT	NYOFCO	19.81	19.81	19.81	19.81	19.81	19.81
SO	BUILDHGT	NYOFCO	19.81	19.81	19.81	19.81	19.81	19.81
SO	BUILDHGT	NYOFCO	19.81	19.81	19.81	19.81	19.81	19.81
SO	BUILDHGT	NYOFCO	19.81	19.81	19.81	19.81	19.81	19.81
SO	BUILDHGT	NYOFCO	19.81	19.81	19.81	19.81	19.81	19.81
SO	BUILDWID	NYOFCO	51.19	70.34	87.36	101.72	112.99	120.83
SO	BUILDWID	NYOFCO	124.99	125.36	121.92	125.36	124.99	120.83
SO	BUILDWID	NYOFCO	112.99	101.72	87.36	70.34	51.19	30.48
SO	BUILDWID	NYOFCO	51.19	70.34	87.36	101.72	112.99	120.83
SO	BUILDWID	NYOFCO	124.99	125.36	121.92	125.36	124.99	120.83
SO	BUILDWID	NYOFCO	112.99	101.72	87.36	70.34	51.19	30.48

APPENDIX: MODEL OUTPUT – PEAK ANNUAL IMPACTS FOR DISCRETE RECEPTORS

```
*** ISCST3 - VERSION 99155 ***     *** NYOFCO
***         05/01/03
                                    *** GENERIC EMISSIONS - DISCREET RECEPTORS
***         20:54:13
**MODELOPTs:
PAGE    8
CONC                           URBAN  ELEV   FLGPOL        GRDRIS

                                *** THE ANNUAL (    5 YRS) AVERAGE CONCENTRATION
VALUES FOR SOURCE GROUP: ALL     ***
                                INCLUDING SOURCE(S):      NYOFCO   ,

                                          *** DISCRETE CARTESIAN RECEPTOR
POINTS ***

                                       ** CONC OF GENERIC  IN MICROGRAMS/M**3
**

      X-COORD (M)    Y-COORD (M)         CONC                          X-COORD (M)
Y-COORD (M)          CONC
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - - - - - - - - - - - - - - - - - - - - - -
        593840.00     4518510.00         0.06696                        592700.00
4518440.00          0.02004              □□□□□□□□□□□□
        593950.00     4518600.00         0.05959
```

APPENDIX: MODEL OUTPUT – PEAK 1 HR IMPACTS FOR DISCRETE RECEPTORS

```
*** ISCST3 - VERSION 99155 ***     *** NYOFCO
***         05/01/03
                                    *** GENERIC EMISSIONS - DISCREET RECEPTORS
***         20:54:13
**MODELOPTs:
PAGE    9
CONC                          URBAN  ELEV   FLGPOL        GRDRIS

                               *** THE   1ST HIGHEST  1-HR AVERAGE CONCENTRATION
VALUES FOR SOURCE GROUP:  ALL       ***
                                 INCLUDING SOURCE(S):      NYOFCO  ,

                                          *** DISCRETE CARTESIAN RECEPTOR
POINTS ***

                                       ** CONC OF GENERIC  IN MICROGRAMS/M**3
**

     X-COORD (M)  Y-COORD (M)        CONC      (YYMMDDHH)              X-COORD
(M)  Y-COORD (M)         CONC      (YYMMDDHH)
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - - - - - - - - - - - - - - - - - - - - - -
       593840.00   4518510.00         2.10766  (91070806)
592700.00   4518440.00         2.00048  (92053112)        □□
       593950.00   4518600.00         2.00526  (91070806)
```

APPENDIX: MODEL OUTPUT - PEAK ANNUAL IMPACTS FOR GRID RECEPTORS

```
*** ISCST3 - VERSION 99155 ***     *** NYOFCO
***         05/01/03
                                    *** GENERIC EMISSIONS - POLAR GRID
RECEPTORS                              ***         18:25:13
**MODELOPTs:
PAGE  19
CONC                          URBAN  FLAT                  GRDRIS

                                                *** THE SUMMARY OF MAXIMUM ANNUAL (
5 YRS) RESULTS ***


                                              ** CONC OF GENERIC  IN MICROGRAMS/M**3
**

NETWORK
GROUP ID                            AVERAGE CONC                 RECEPTOR  (XR, YR,
ZELEV, ZFLAG)   OF TYPE  GRID-ID
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - - - - - - - - - - - - - - - -

ALL      1ST HIGHEST VALUE IS       0.19616 AT (  593646.44,  4517513.00,
0.00,      0.00)  GP   POL1
         2ND HIGHEST VALUE IS       0.19087 AT (  593569.81,  4517577.00,
0.00,      0.00)  GP   POL1
         3RD HIGHEST VALUE IS       0.18427 AT (  593597.13,  4517463.50,
0.00,      0.00)  GP   POL1
         4TH HIGHEST VALUE IS       0.18049 AT (  593033.56,  4517513.00,
0.00,      0.00)  GP   POL1
         5TH HIGHEST VALUE IS       0.17904 AT (  593532.81,  4517540.00,
0.00,      0.00)  GP   POL1
         6TH HIGHEST VALUE IS       0.17586 AT (  593723.00,  4517448.50,
0.00,      0.00)  GP   POL1
         7TH HIGHEST VALUE IS       0.17068 AT (  593110.19,  4517577.00,
0.00,      0.00)  GP   POL1
         8TH HIGHEST VALUE IS       0.16874 AT (  593686.44,  4517570.00,
0.00,      0.00)  GP   POL1
         9TH HIGHEST VALUE IS       0.16576 AT (  592957.00,  4517448.50,
0.00,      0.00)  GP   POL1
        10TH HIGHEST VALUE IS       0.16533 AT (  593661.38,  4517387.00,
0.00,      0.00)  GP   POL1


 *** RECEPTOR TYPES:  GC = GRIDCART
                      GP = GRIDPOLR
                      DC = DISCCART
                      DP = DISCPOLR
                      BD = BOUNDARY
```

Exhibit D

See attached.

SYNAGRO

A Residuals Management Company

December 3, 2002

RE: Air Title V Facility Permit, ID: 2-6007-00140/00011

Bert Breitberg
New York State
Department of Environmental Conservation
47-40 21st Street
Long Island City, NY 11101

Dear Mr. Breitberg:

The enclosed material is a compilation of available scientific data relevant to analyzing the potential for releases to the ambient environment of pathogens, bacteria and spores from biosolids at the NYOFCo facility, in compliance with Item 38.1 of the NYOFCo Air Title V Facility Permit.

Research and papers most relevant to pelletizing operations is included in this submission. The reports conclude that heat drying is an acceptable method to control pathogens and vectors. Though data specific to any drying/pelletizing operations was not found, the Environmental Protection Agency and National Research Council conclude that processing biosolids in accordance with 40 CFR Part 503 does not fail to protect public health.

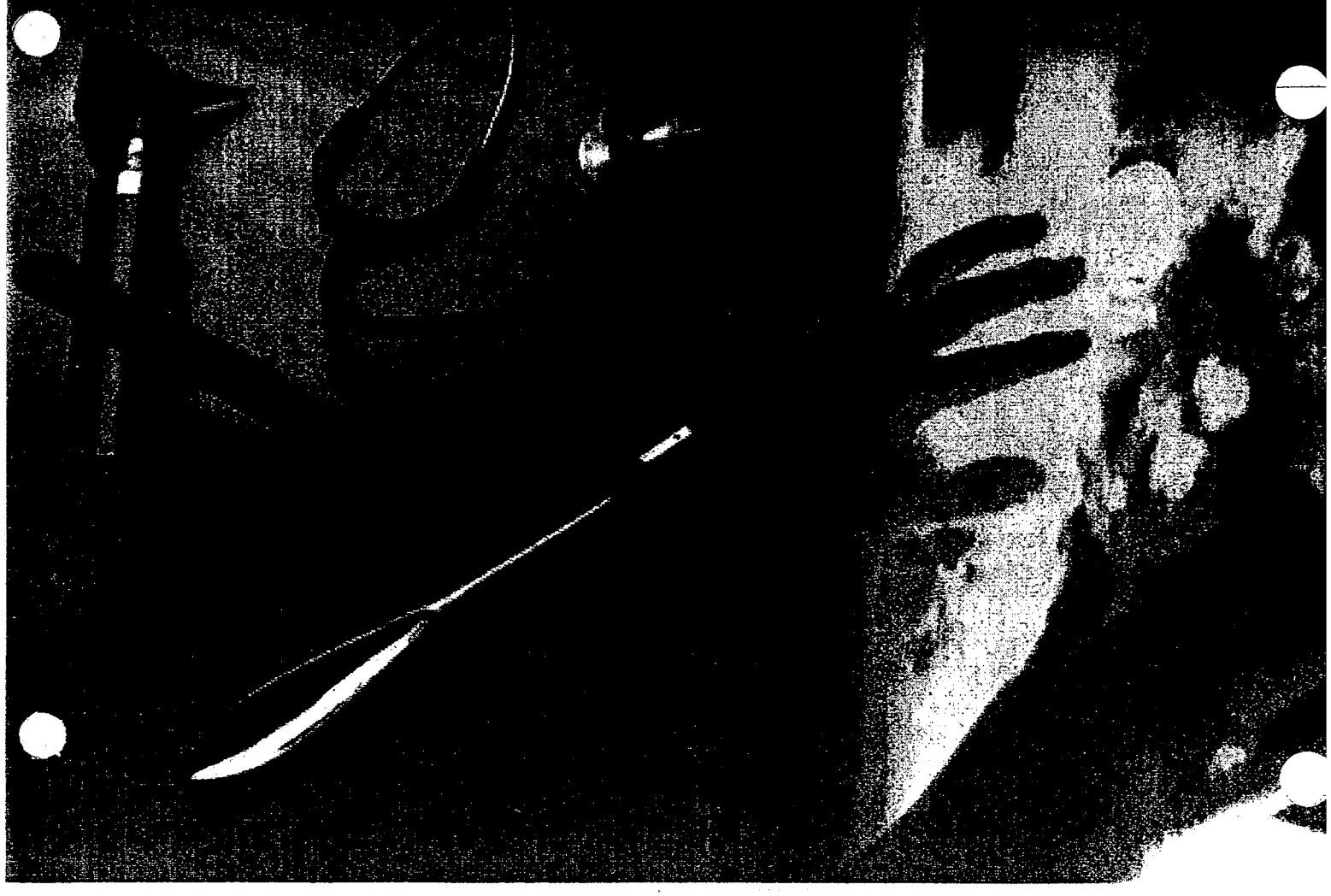
Sincerely,

Peter Scorziello
Plant Manager

Cc: Sam Leibleich
Gail Hintz Esq.
Alexis Vitone

RISK EXPOSURE

Are treated wastewater and biosolids hazardous to your health?



Since 1966, more than 100 articles have been published concerning the risks to operators or the public from exposure to wastewater and biosolids. However, because many of the articles appeared in periodicals not commonly associated with the environmental profession, you may not be familiar with the wealth of information that exists. A summary of several articles selected to represent the breadth of this health research is presented below (see sidebar, p. 40, for full citations).

Wastewater Exposure

Mortality risks. Wastewater treatment plant operators are not dying at rates greater than the general population, according to a 1980 study by P.S. Gartside, B. Specker, P.E. Harlow, and C.S. Clark. They studied retired employees of the Metropolitan Sanitary District of Greater Chicago (now the Metropolitan Water Reclamation District of Greater Chicago) who had worked at the district between 1960 and 1969. Compared to the white male population of the state of Illinois, they noted that fewer of the retirees had died than would be expected (704 deaths rather than 1075). This correlated to a 65.5 standard mortality ratio (SMR; the number of observed deaths in a study population divided by the number of expected deaths and then multiplied by 100), which was statistically insignificant.

Using work records and death certificates for 402 of the 704 decedents, researchers determined that, regardless of whether the retirees had died of neoplasms, heart disease, respiratory system disease, accidents, or other causes, the related SMRs were statistically insignificant. Nor did it matter what kind of job the retirees had held or whether they had worked at the plant for 1 to 8 years, 9 to 16 years, or 17 years or longer. (Because of a lack of impacts and funding, a final report never was published. The only data summary is in the interim report.)

Cancer risks. Wastewater treatment plant operators are no more likely to develop cancer than someone in the general population, according to a 1991 study by Lafleur *et al.* Researchers studied 487 full-time, white male employees who had worked at least 5 years at the City of Buffalo (N.Y.) Wastewater Treatment Plant and determined that the death rate due to all causes was similar to the general population (SMR = 0.91, 0.77 to 1.07). They also separated operators into exposed and unexposed groups, depending on their chance of having direct contact with wastewater. They determined that the SMR was 0.55 (0.33 to 0.88) for the unexposed group and 1.00 (0.84 to 1.19) for the exposed group. Socioeconomic differences were not accounted for in this study, researchers noted, so the comparison between exposed and unexposed groups may not be valid. Also, they said, exposure was based on job title rather than on individual assessment.

Airborne pathogen risks. Concerns about infections caused by airborne pathogens from wastewater treatment plants have persisted for decades. In 1966, for example, C.W. Randall and J.O. Ledbetter enumerated the numbers and types of bacteria emitted from an activated sludge process at a plant in Austin, Texas. They found that nearly 1200 bacteria colonies would propagate on an agar from each cubic foot of air emitted from an activated sludge aeration basin. Six percent of these bacteria were identified as respiratory pathogens, such as *Klebsiella pneumoniae*.

Subsequently, researchers determined that the number of *Klebsiella* inhaled by a wastewater treatment plant worker would be insufficient to cause an infection, according to a 1973 study by J.O. Ledbetter, L.M. Hauck, and R. Reynolds. Furthermore, more than half the particles in aerosols containing the bacteria were larger than 6 microns and therefore considered non-respirable.

To investigate this finding, Ledbetter sent a questionnaire to major water and wastewater treatment facilities in Texas. The questionnaire asked workers how long they had worked at the plant and how often they had pneumonia, flu, and colds. Based on responses from 287 wastewater and 383 water treatment plant operators, researchers determined that while the likelihood of getting pneumonia was nearly identical — 2.07 and 1.99 cases per 1000 person years of employment for wastewater and water operators, respectively — wastewater treatment plant operators were more likely than water operators to get colds and flu. Researchers noted, however, that questionnaire responses were difficult to interpret because of the lack of an exact definition of each illness and problems with respondent recall. Because pneumonia usually requires medical intervention, they said, the data for pneumonia were probably more reliable than those for colds and flu.

Experience-based risk. Employees' risk of illness typically decreases as their length of employment at a wastewater treatment plant increases, according to a 1979 study by C.S. Clark, *et al.* To determine the potential health effects of biological agents in wastewater on treatment plant operators and their relatives, researchers performed a prospective seroepidemiologic study that analyzed stool and blood samples from operators, sewer maintenance workers, and their families in Cincinnati, Chicago, and Memphis. They then compared the results to similar analyses of water treatment plant workers, light and gas company workers, and highway maintenance workers. Overall, wastewater treatment plant employees were no more likely to be sick than any other group. Those who had worked at the plant for less than 2 years, however, were two to four times more likely to suffer gastrointestinal illness than those who had worked there longer. This would suggest that any study evaluating the health of operators exposed to wastewater or biosolids should consider the length of employment.

Risks to vulnerable populations. A new wastewater treatment plant in Tigard, Ore., did not affect the incidence of communicable diseases as measured by the absence rate at a nearby elementary school, according to a 1980 study by D.E. Camann *et al.* For 9 months each year, children spent about 35 hours per week in the school

and playground, which was only 150 ft (46 m) from the plant's uncovered aeration basin. Researchers monitored the airborne concentration of microorganisms and the students' absence rate for 2 years and found that the absence rate at the exposed school not only declined but also was better than the rate at five unexposed schools.

Biosolids Exposure

PCB risks. Before industrial pretreatment programs were implemented, researchers discovered that the wastewater treatment plant in Bloomington, Ind., had between 19 and 47 mg/L of polychlorinated biphenyls (PCBs) in its effluent and 300 ppm of PCBs in its sludge, according to a 1977 study by D. Jordan. The PCBs had been discharged to the city's collection system from a Westinghouse Electric Co. (Monroeville, Pa.) capacitor manufacturing plant that began production in 1957. Sludge from Bloomington's wastewater treatment plant, which treated the discharge from the capacitor manufacturing facility, was used in home gardens in the region. Although the sludge contained six times the 40 *CFR* 257 PCB limit for land-applied sludge (50 ppm), only the factory workers demonstrated statistically significant elevated blood PCB levels, according to a 1980 clinical survey by E.J. Baker, *et. al.*

"We found only slight evidence in this study that exposure to PCB in sewage sludge had increased serum PCB levels in persons who had used contaminated sludge for garden fertilizer," researchers said. "The range of serum PCB concentrations observed in the nonoccupationally exposed population of Bloomington, Indiana — sludge users and nonusers alike — was similar to that reported in other North American surveys."

Pathogen risks. The pathogen exposure risks of land-applied biosolids depend on distance and wind speed, according to a 2000 study by S.E. Dowd, *et al.* They modeled bacteria and virus release rates from both point and area sources at a field where anaerobically digested, dewatered biosolids were land-applied, taking into account the effects of wind velocity and distance on pathogen levels. They then used dose-response models to characterize the risk of bacteria and viruses infecting workers, as well as the probable risk for bacterial and viral infections resulting from point and area sources 100, 500, 1000, and 10000 m away at wind speeds of 2, 5, 10, and 20 m/s and exposure times of 1, 8, and 24 hours (see table, right). They noted that the risk drops as one moves farther from the source and that the virus release rate was much lower than the bacteria release rate (probably because biosolids contain fewer viruses than bacteria). The authors noted that the calculated risks reflected worst-case scenarios because not everyone becomes ill after exposure. In addition, the model did not account for biosolids incorporation into the soil, a standard land-application practice that greatly reduces the exposure risk.

Risks to employees. Sludge can make operators sick if sanitary conditions at a wastewater treatment plant are poor, according to a 1978 study by I. Mattsby and R. Rylander. They studied workers at a Gothenburg, Sweden, wastewater treatment plant who had reported recurring episodes of acute illness and diarrhea. Given that the plant's sludge drying process produced dust levels between 0.5 and 4.0 mg/m^3 and airborne bacteria concentrations between 104 and 107 colonies/m^3, researchers were not surprised that 13% of workers reported acute diarrhea that lasted for approximately a day after dust exposure.

Direct contact with wastewater and untreated sludge produces responses in an operator's immune system, according to a 1991 study by K. Varadarajank, *et al.* They analyzed the blood of 20 control subjects and 20 employees between the ages of 20 and 55 who had direct contact with treated wastewater and worked for at least 5 years at a farm in Muradia City, Tamil Nadu receiving 2 mgd (7600 m^3/d) of treated wastewater that had not been disinfected, as well as sludge that had not been stabilized or disinfected and was separated physically onsite.

Blood analysis results showed that the farm employees had 10% more leucocyte/mm^3 and 4.20% higher levels of *Eosinophis* than the control group. The employees also had higher total protein and albumin levels, which may be attributed to adaptive responses from exposure. In addition, the employees had 57.9% higher Ig-G levels, 59.5% higher Ig-A levels, and 68.9% higher Ig-M levels. Increased Ig-G levels indicate exposure to such diseases as monoclonal gammopathies, rheumatoid arthritis, infectious hepatitis, infectious mononucleosis, tuberculosis, leprosy, and parasitic infections. Increased Ig-A levels may indicate chronic, oral exposure to bacterial products, viruses, and parasites. Increased Ig-M levels indicate a primary antibody response to all antigens.

Risks to farmers. Land-applied biosolids were not associated with higher incidence of disease in farm families, according to a 1985 article by R.C. Dorn, *et al.* They studied workers and residents on farms where sludge had been applied and those on farms in similar areas where no sludge had been applied and found no significant differences in reported episodes of nausea, headaches, digestive,

Risk of Infection Associated with Contacting a Virus or Bacteria Particle

(8-hour exposure time 100 m from the source)

	Wind speed			
Pathogen source	2 m/s	5 m/s	10 m/s	20 m/s
Area-source virus particle	0.395	0.936	0.99	1.0
Point-source virus particle	0.19	0.71	0.96	0.99
Area-source bacteria particle	0.033	0.076	0.132	0.213
Point-source bacteria particle	0.12	0.23	0.33	0.44

For More Information

Baker, E.J., Landrigan, P.J., Glureck, C.J., Zack, M.M., Liddle, J.A., Bruse, V.W., Houseworth, W.J., and Needham, L.L. (1980) "Metabolic Consequences of Exposure to Polychlorinated Byphenyls (PCB) in Sewage Sludge," *American Journal of Epidemiology*, 112:1.

Camann, D.E., Harding, J.H. and Johnson, D.E. (1980) "Wastewater Aerosol and School Attendance Monitoring at an Advanced Wastewater Treatment Facility: Durham Plant, Tigard, Oregon." *Wastewater Aerosols and Disease, Proceedings of a Symposium*. EPA-600/9-80-028.

Clark, C.S., Van Meer, G.L., Linnemann, C.C., Bjornson, A.B., Gartside, P.S., Schitt, G.M., Trimble, S.E., Alexander, D., and Cleary, E.J. (1979) "Health Effects of Occupational Exposure to Wastewater." *Wastewater Aerosols and Disease, Proceedings of a Symposium*. EPA-600/9-80-028.

Dorn R.C., Reddy C.S., Lamphere D.N., Gacuman J.V., Lanese, R. (1985) "Municipal Sludge Application on Ohio Farms: Health Effects." *Environmental Research*, 38:332-359.

Dowd, S.E., Gerba, C.P., Pepper, I.L., Pillai, S.D. (2000) "Bioaerosal Transport Modeling and Risk Assessment in Relation to Biosolids Placement." *Journal of Environmental Quality*, 29:243-348.

Gartside, P.S., Specker, B., Harlow, P.E., Clark, C.S. (1980) "Interim Report on a Mortality Study of Former Employees of the Metropolitan Sanitary District of Greater Chicago." *Wastewater Aerosols and Disease: Proceedings of a Symposium*. EPA-600/9-80-028.

Jordan, D. (1977) "The Town Dilemma." *Environment*. 19:2, 6-15.

Lafleur et.al. (1991) "Retrospective Cohort Mortality of Cancer among Sewage Plant Workers." *American Journal of Industrial Medicine*. 19(1):75-86.

Ledbetter, J.O., Hauck, L.M., and Reynolds, R. (1973) "Health Hazards from Wastewater Treatment Practices." *Environmental Letters*. 4:3, 225-232.

Mattsby, I. and Rylander, R. (1978) "Clinical and Immulogical Findings in Workers Exposed to Sewage Dust." *Journal of Occupational Medicine*. 20:10. 690-692.

Randall, C.W. and Ledbetter, J.O. (1966) "Bacterial Pollution from Activated Sludge Units." *American Industrial Hygiene Association Journal*. 27:6. 506-519.

Varadarajank K., K. Kannan, K. Plaiwal, A. Mani, and V.S. Balasubramanian (1991) "Effect of Sewage Pollution of the Health Status of Sewage Farm Workers." *Environmental Contamination and Ecotoxicology*. 47(5):646-652.

and upper and lower respiratory problems.

Risks to neighbors. In November 1998, a lawsuit filed in Rockingham County (N.H.) Superior Court claimed land-applied biosolids were responsible for the death of a Greenland, N.H., man. The case was settled early in 2002, and while the settlement terms are confidential, the plaintiffs issued the following statement:

> "The science developed in this case did not prove that the sewage sludge ... applied on the Hughes Field in Greenland, N.H., in October 1995 caused or contributed to Shayne Conner's death, nor did the science prove that sewage sludge caused any of the injuries or illnesses the other residents of Tuttle Lane allegedly suffered."

Summary

In spite of exposure to disease-causing agents in wastewater and biosolids, operators are not more at risk for serious health consequences (mortality, cancer). Furthermore, standard personal hygiene and workplace sanitary precautions decrease the chance of morbidity or acute illnesses. No increase in disease or mortality in general populations next to wastewater treatment facilities or treated biosolids land-application sites has been reported in peer-reviewed literature.

These findings would confirm the conventional supposition that if operators, who are subjected to significantly higher exposures, are not suffering any adverse consequences, then a normally healthy person who lives next to an application site or treatment plant will not be affected.

***Richard D. Kuchenrither**, Ph.D., PE, is a senior vice president at Black & Veatch (Kansas City, Mo.). **Sybil Sharvelle** is a graduate student, and **JoAnn Silverstein**, Ph.D, PE, is a professor in the Department of Civil, Environmental & Architectural Engineering at the University of Colorado (Boulder).*

HEALTH EFFECTS AND RISKS ASSOCIATED WITH BIOSOLIDS

Paul Chrostowski, Ph.D., QEP
CPF Associates, Inc.
7708 Takoma Avenue
Takoma Park MD 20912
pc@cpfassociates.com

Accepted for Presentation
Annual Residuals and Biosolids Management Conference
Water Environment Federation
Austin, TX
March 3-6, 2002

ABSTRACT

Human health related complaints have been received by the biosolids industry from residents around points of generation, composting facilities, and land application sites. These complaints have ranged in severity from odor and headache to death and have implicated pathogens and gases as potential causative agents. The application of scientific methods addressing causation is necessary to determine if these claims have any validity. This paper will introduce tools that can be used by facility owner/operators to assess causation in health claims involving potential exposure to biosolids. Causation criteria including Koch's postulates, the Bradford Hill criteria, and concepts from risk assessment will be introduced and applied. Case studies involving investigation of mortality and ammonia exposure claims associated with land application of Class B biosolids will be presented. The results of these case studies show that exposure to biosolids did not cause the health effects that were claimed.

KEYWORDS

Biosolids, health, risk, ammonia, morbidity, mortality, causation.

INTRODUCTION

Owners and operators of facilities that generate or manage biosolids have received a variety of complaints from facility neighbors regarding the health effects of exposure to biosolids. These complaints have been exacerbated by anti-biosolids activists who recognize the significance of health in decision making for biosolids management. From the federal to the local level, information about health concerns often rises to the forefront of debates over siting, permitting, and operation of biosolids facilities. Health claims are often reported in the media (e.g. Snyder & Kunkle 2001, Gibb 2000) without a scientific examination of their validity.

Anti-biosolids activists often make claims regarding disease causation that are never substantiated or even examined using scientific principles. For example, Lewis (2000 and 2001) claims that individuals exposed to "sewage sludge" have reported a litany of symptoms and diseases including severe headaches, skin lesions or rashes, mucous production, nausea, difficulty in breathing, burning in the eyes, nose mouth, throat and lungs, fever, flu-like symptoms, diarrhea, and death. Before they can be accepted as valid, these claims must be examined using scientific principles to determine if exposure to biosolids caused the disease in question. This may be readily accomplished using tools of causation analysis that have been used by scientists for over 100 years.

This article presents an overview of three of these tools – epidemiologic causation, microbiological causation, and risk assessment. The tools are then used in two case studies to evaluate claims made concerning alleged health effects of exposure to biosolids.

EPIDEMIOLOGIC CAUSATION

A critical element in evaluating claims associated with alleged exposure to biosolids is whether the exposure caused the disease. Causation may be thought of as a chain of events that links an injury to toxic substance or pathogen exposure. This chain must not be broken for causation to be demonstrated. In evaluating a chain of causation for a specific injury or illness, analysts usually start by evaluating the illness and then determining whether the subject was actually exposed to the agent of concern. The exposure analysis is based on biomonitoring, dosimetry, environmental monitoring, mathematical modeling, questionnaires, or a combination of these methods. Once it has been determined that exposure has occurred, a toxicology/microbiology/epidemiology review is conducted to determine if a health hazard exists. The existence of a health hazard is then linked to the exposure through risk assessment concepts such as dose-response quantification. Finally, confounding causes of the illness are investigated. Only when exposure has occurred at a level sufficient to elicit an adverse health effect that is not explainable by other causes can the exposure be causally linked to the disease.

In 1965, Sir Bradford Hill developed the first general criteria for evaluating causation in epidemiologic studies (Hill 1965). Since then consensus criteria have evolved in the scientific literature (Doll 1984, Lillienfeld & Stolley 1994) for evaluating claims of causation. These criteria may be distilled into a few general principles for assessing causation in individuals:

- **Hazard identified/qualitative toxicology**. Is the chemical (or microorganism) capable of causing the alleged disease in the person claiming damage?
- **Exposure and Dose Response**. Did the person claiming the disease contact the hazardous chemical (or pathogenic microorganism) at a sufficient level (duration, frequency, intensity) to result in an injury?
- **Time course of disease**. Was exposure temporally related to the injury given appropriate considerations of disease latency?

- **Confounders/differential diagnosis**. Are there possible alternative causes for the disease?
- **Analysis of scientific plausibility**. Do toxicologic, epidemiologic, microbiological, chemical, and clinical data present an internally consistent and coherent view of the disease?

Epidemiologic studies deal with populations rather than individuals; for example, a population consisting of all residents living within a given radius of a land application site. Epidemiologic studies typically involve a comparison of the incidence of an effect in an exposed group to the incidence in a control group. In addition to the individual criteria mentioned above, epidemiological criteria for causation include the numerical strength of association between exposure and health effect, consistency of human associations among populations, and agreement with experimental evidence (e.g. from animal studies). The Ohio farm study (Dorn et al. 1985) is an example of a well conducted epidemiologic study involving potential exposure to pathogens associated with the land application of biosolids. This study concluded hat there was no elevated pathogenic risk for people or livestock associated with the land application.

Another criterion that is common to both individual and epidemiologic causation is that of scientific coherence. In essence, coherence means that the results of the study are in agreement with accepted views. Although it is difficult to make generalizations about generally accepted scientific views, most scientists are in agreement that studies must be conducted in accordance with the scientific method, that studies should be controlled, that data should be reproducible by independent investigators, that data have an adequate degree of quality assurance, and that results are published or presented in an open forum of scientific peers. In a particular academic discipline, results should be consistent with the body of scientific literature available on the subject.

In addition to scientific criteria for causation, several recent court cases have resulted in the adoption of legal criteria for the acceptability of scientific expert testimony. Although most applicable to the legal arena, these criteria are generally useful to anyone facing purportedly scientific evidence concerning alleged causation. In general, expert testimony to be admissible in evidence is required to be:

- Grounded in the methods and procedures of science,
- Based upon more than subjective belief or speculations,
- Supported by appropriate validation,
- Helpful in the case at hand.

At the simplest level, it can easily be seen that hypotheses to the effect of "biosolids contain pathogens (or toxic chemicals); pathogens or toxic chemicals cause disease; individuals have been reported to be sick near land application sites therefore biosolids cause disease" fail to stand up under the scrutiny of either scientific or legal causation criteria.

MICROBIOLOGICAL CAUSATION

Infectious diseases are a significant cause of morbidity and mortality in the United States. Millions of cases of infectious disease are reported annually to the Centers for Disease Control and Prevention (CDC). Through September of 2001, the CDC (2001) has reported approximately 40,000 cases of gastrointestinal diseases alone caused by specific microorganisms. The causative agents for infectious diseases range from viruses (e.g. HIV, hepatitis) to bacteria (*E. Coli*, *Salmonella*) and protozoa (*Cryptosporidium, Giardia*). The consequences of these diseases may range from mild conditions such as stomach upset through severe illness and death. Most cases of infectious disease are mild and not reported to health authorities. For example, common colds, mild influenza and mild gastroenteritis usually go unreported.

Many claims regarding potential illness associated with alleged exposure to biosolids may be attributed to infectious diseases. For example, in the NIOSH LeSourdesville study (NIOSH 2000), worker complaints of gastroenteritis involved symptoms that are associated with infections with common bacteria such as *Shigella, Salmonella*, and enteropathogenic *E. Coli* species. Given the common nature of most of the diseases and the ubiquitous presence of microorganisms in the environment, the question of causation or the link between a microbial pathogen in biosolids and an illness is an important one.

The subject of microbial causation of disease was first addressed by Robert Koch in 1884. Koch's Postulates, which are still used today, state (Brooks et al. 2001):

- The microorganism should be found in all cases of the disease and its distribution in the body should be consistent with the observed lesions;
- The microorganism should be grown in pure culture for several generations;
- When the pure culture is inoculated into susceptible animal species, the typical illness must result; and
- The microorganism must be capable of being isolated from the experimentally produced disease.

More recent interpretations of Koch's Postulates involve DNA identification of microorganisms (Brooks et al. 2001).

There are several keys to the application of Koch's Postulates to claims of illness. First, the illness must have an infectious etiology. Claims of cancer, cardiovascular disease, and reproductive effects are not likely to be of microbiological origin whereas claims of gastroenteritis and upper respiratory illness may well have an infectious source. Second, an actual microorganism species must be identified using standard protocols. Normally this involves obtaining a sample from the patient, which is cultured and tested. At a minimum, testing should involve morphological and biochemical testing. To avoid ambiguity, most contemporary forensic investigators rely on DNA testing. In the NIOSH LeSourdesville study (NIOSH 1999), for example, bacterial species were not actually identified. Rather, bacteria genera were identified using morphology only. This is not an acceptable practice for demonstrating causation. For example, identification of the

genus, *Bacillus*, is meaningless. *Bacillus* includes the highly pathogenic *Bacillus anthracis* (the cause of anthrax and not found in biosolids) in addition to the non-pathogenic and very common soil bacteria *Bacillus subtilis*. In this case, the identification of the correct species is critical not only for causation but for treatment of a potentially exposed individual.

Quality assurance and quality control (QA/QC) are also important for microbiological measurements. Precision, accuracy, representativeness, sensitivity, and reproducibility of measurements all need to be evaluated for each claim. Requirements for quality assurance in the medical microbiological laboratory have been discussed in the literature (Mahan & Manuselis 2000). Typical medical microbiological quality assurance plans include equipment calibration, equipment QC, reagent QC, personnel competency, use of stock cultures, and development and adherence to a QC manual.

In addition to the detection of the microorganism in the potentially infected individual, it must also be detected in the possible source. Many pathogens do not occur in raw sludge and most pathogens do not occur in Class B biosolids. EPA (1995b) and Straub et al. 1993 report that the most significant pathogenic bacteria in sludge include *Campylobacter jejuni*, enteropathogenic *E. coli, Leptospira* spp, several *Salmonella* species, several *Shigella* species, *Vibrio cholorae*, and several *Yersina* species. Dumontet et al. (2001) and EPA (1999) report additional primary and opportunistic bacteria species that have been isolated from wastewater, sludge or biosolids. Reports of airborne bacteria that are not commonly associated with biosolids (e.g. NIOSH 1999) should be viewed with caution. For particular cases, it is critical that the exact organism that was identified in the patient also be identified in the potential biosolids source. As with medical microbiological methods, environmental microbiological testing methods must be performed with appropriate quality assurance and quality control (APHA et al 1998). For risk assessment purposes, it is also desirable to quantify the microorganisms in the source. This allows for the subsequent use of mathematical exposure and dose-response models.

Once an exact microorganism has been identified in both patient and source, the information may be used in the context of a quantitative microbiological risk assessment, which will be discussed in further detail in the following section.

RISK ASSESSMENT

Risk assessment is a formal process for combining scientific information to determine the probability that exposure to an agent will result in an adverse impact. Many of the scientific concepts of risk assessment are linked to the concepts of scientific causation noted above. Risk assessment has been defined by the National Academy of Sciences (NAS 1983) and the EPA (1989) to be a process based on the following four components: identification of chemicals of potential concern, exposure assessment, a toxicology evaluation (including a hazard identification and a dose-response quantification) and risk characterization. Health risk assessments have been used by independent scientists and regulatory agencies since the mid-1970s to assess and regulate chemicals in the

environment. The 503 rules that govern all methods of beneficial use of biosolids in the United States were based on a multiple-chemical, multiple pathway risk assessment (EPA 1995a).

Although a full discussion of risk assessment principles is beyond the scope of this discussion, a few fundamental concepts will be discussed here. The reader is referred to the literature (Kolluru et al. 1996, Patrick et al. 1994, Haas et al. 1999) for further discussion of risk assessment principles and techniques. Probably the most fundamental concept of contemporary risk assessment is the idea of a dose-response relationship. Simply put, the probability or severity of an adverse effect is related to the amount of exposure to the agent causing the effect. For most effects and most chemicals, a toxicological threshold exists. Exposure to levels below this toxicological threshold will not result in any adverse effect. Once the threshold has passed, higher exposure will result in a progressively higher probability of an adverse effect. For chemicals, the level immediately above threshold that can result in effects is often known as the Lowest Observable Adverse Effect Level (LOAEL); below this point, the dose-response curve is characterized by no adverse effect levels (NOAELs). For microorganisms, the comparable level is known as the minimum infective dose (MID). Unless the LOAEL or MID is reached, it is unlikely that the chemical or microbiological agent will be able to cause disease. Most risk assessments involve measuring or modeling a level of exposure, which is subsequently compared to various points on the dose-response curve (such as the LOAEL) to determine the probability of an effect. Regulatory agencies typically develop numerical standards by applying safety factors to no effect levels on the dose-response curve.

Anti-biosolids activists (Harrison et al. 1999) have criticized EPA for limiting the scope of the risk assessment of the 503 rules to metals. Specifically, these critics charge that EPA should have performed risk assessments for pathogenic micro-organisms and other chemicals including air toxics. In conducting a regulatory risk assessment, it is not always necessary to address every eventuality as long as the principal threats are addressed. Due to persistence, toxicity, and mobility in the foodchain, certainly heavy metals constitute at least some of the principal threats associated with land application of biosolids and EPA was justified in its focus. In addition, the regulatory framework of the Clean Water Act allows for both technology-based and risk-based standards. With respect to pathogens, EPA opted for a technology-based standard (EPA 1999). However, methods do exist for performing risk assessments of other components of biosolids such as air toxics (Patrick et al. 1994) and microorganisms (Haas et al. 1999). These methods may be applied on a site-specific basis when claims about effects associated with biosolids are made.

CASE STUDIES

Two case studies drawn from current claims concerning exposure to biosolids will be used to illustrate application of the principles of causation. The first involves an examination of allegations concerning biosolids associated mortality. The second

involves claims made concerning health effects associated with ammonia emissions from biosolids.

Claims Involving Biosolids and Alleged Mortality

The media (Snyder and Kunkle 2001, Gibb 2000) have reported two cases in which two individuals allegedly became ill and died following exposure to land applied biosolids. Shayne Connor, a 26 year old male from Greenland NH, died in 1995 approximately one month following land applications of class B biosolids on a field near his home. Lewis et al. (2000) and Lewis (2001) have alleged that Connor's death was associated with airborne exposure to an unidentified pathogen following sensitization with ammonia. Lewis' argument is through analogy rather than evidence-based, "It would be unreasonable to expect that the Class B sewage sludge applied to the Rosemund Hughes field did not possess similar amounts of all the normal chemical and biological constituents of lime-stabilized Class B sewage sludge that are responsible for illnesses occurring among people who inhale or ingest the material within the one-year period...". Tony Behun, an 11 year old male in Osceola Mills, PA allegedly died in 1994 following riding a bicycle through a field where biosolids had been applied. Lewis' theory with Behun is similar to his theory with Connor. Lewis (Gibb 2000) believes that Behun was rendered vulnerable to bacteria due to the assumed presence of lime and ammonia in the biosolids.

The autopsy of Shayne Connor showed no cause of death. In the context of causation, this basically breaks the first link in the chain. Indeed, no findings from the autopsy support the hypothesis that Connor's death was due to upper or lower respiratory tract injury and there is no evidence that a toxin, gas, or environmental agent affected Connor. Without a cause of death, there is no identifiable disease or injury and thus, there can be no causation. Mere proximity to a land application site does not meet criteria for exposure assessment. Probably most significantly, however, a differential diagnosis shows that Connor's death may have been more likely than not associated with a sudden catastrophic cardiac event, such as cardiac arrhythmia.

The literature also fails to support an hypothesis of airborne transmission of pathogens from land applied biosolids. In the LeSourdesville study (NIOSH 1999), the total heterotrophic plate counts reported by NIOSH at the land application site were typical of background levels over untreated fields (Lighthart and Shaffer 1995). Pillai et al. (1996) failed to find Salmonella, indicator organisms, or coliphages in the air downwind from a land application site. Thus, the hypothesis that Connor's death was associated with airborne pathogens lacks scientific coherence.

Behun's death has been extensively investigated by the Pennsylvania Departments of Environmental Protection and Health. The results of this investigation confirmed that Behun died of an infection, however, it was caused by a pathogen, *Staphylococcus aureus*, not known to be found in biosolids. Sampling at the application site did not show the presence to *S. aureus* (DEP 2000). The Departments also concluded that biosolids were not a suitable medium for growth of this pathogen. A third conclusion was that the

pathogen is carried by between 20% to 30% of the general population and there were likely to be numerous routes of transmission, aside from biosolids, where Behun could have been exposed. In this case, although a pathogen was isolated from the subject, it was not found to be linked to the land application site.

Claims Involving Exposure to Ammonia from Biosolids

In the case of Shayne Connor discussed above, Lewis et al. (2000) alleged that exposure to toxic gases including ammonia and dimethyldisulfide was a precipitating factor in Connor's illness and illness suffered by others in the neighborhood. Lewis et al. (2000) stated that Connor was exposed to 260 ppm of ammonia and between 24 and 110 ppm of dimethyldisulfide emitted from lime stabilized Class B biosolids over the period of a month. When this research was analyzed in detail, it as found to be based on an unsubstantiated assumption that there was a steady state concentration of ammonia over the land applied biosolids of 1000 ppm that persisted for a month. It was also based on inaccurate air dispersion modeling and inappropriate assumptions regarding exposure.

This claim fails to meet the scientific criterion of coherence – a complete search of the scientific literature failed to produce any clinical or epidemiological studies in which exposure to gases from land applied biosolids resulted in human mortality. In addition, the theory that exposure to a reactive gas (such as ammonia) can predispose an individual to an infectious disease has only been reported in cases where there is actual trauma to tissues which consequently reduces defenses against infection. No such trauma was observed during Connor's autopsy. Finally, this claim lacks plausibility. Concentrations of ammonia this high have never been reported at land application sites and simple mass balance calculations demonstrate that there was insufficient nitrogen in the biosolids to result in the emissions of ammonia claimed by Lewis et al. (2000). The concentration of 1000 ppm assumed by Lewis et al. (2000) was, in fact, based on a measurement from the exhaust air of a composting facility, rather than from a land application site (Haug 1993). The source characteristics of an enclosed composting facility completely difference than those of a land application site. The author of the publication relied on by Lewis et al. (2000) has calculated that a maximum ammonia concentration over the land application in question would not exceed 3 ppm based on a mass balance (Haug 2000).

This type of problem is amenable to classical risk assessment techniques. The chemicals of concern had already been identified by the claimant to be ammonia and dimethyldisulfide. For purposes of this analysis, we will limit our discussion to ammonia since Lewis et al (2000) claimed it was present at much greater levels than dimethyldisulfide. The risk assessment consisted of an analysis of the source and emissions of ammonia, an exposure assessment, and a comparison to toxicological thresholds.

Emissions of ammonia from the land-applied biosolids were calculated using a mass balance approach. Information from the literature indicated that application method, pH and temperature were significant factors in determining volatilization (Beauchamp et al. 1987), thus, they were used in the mass balance modeling. In addition, other research

(Koelliker & Kissel 1988) has shown that emissions of ammonia from land-applied biosolids will follow an exponentially declining curve. Many studies have documented ammonia volatilization behavior from biosolids, fertilizer, or untreated sludge (Donovan & Logan 1983). These studies show that rates can be as high as 30% initial with rapidly declining emissions after that. Based on a mass balance and the methods reported in the literature, a maximum emission rate for ammonia from the biosolids in question was calculated to be 18.7 $\mu g/m^2$/sec for the first 12 hours following application. As anticipated based on literature reports, this rate declined exponentially. By the fifth day, for example, the emission rate was 4.2 $\mu g/m^2$/sec and after a month it had dropped to 0.4 $\mu g/m^2$/sec.

The exposure assessment used the mass balance emission rates as an input to EPA's ISCST air dispersion model. Site-specific meteorological data were used to yield the most reliable estimates of exposure. Concentrations of ammonia at Connor's residence were modeled for a period of a month preceding his death. The maximum modeled air concentrations of ammonia at Connor's residence were 0.012 ppm for a 24-hour value and 0.080 ppm for the 1-hour maximum value. For the entire exposure period, the concentrations for the 1-hour and 24-hour concentrations were 4 to 17-fold lower than the maxima.

Toxicological dose-response data for ammonia exposure have been developed by many regulatory and public health agencies. ATSDR (1990) uses a threshold value incorporating several safety factors of 0.3 ppm for long-term exposures and 0.5 ppm for short-term exposures. EPA (2000) uses a reference concentration also incorporating safety factors of 0.14 ppm for long-term (lifetime) exposure to ammonia. The American Industrial Hygiene Association (AIHA 1996) has developed threshold concentrations for short-term exposure. In this context, AIHA reports that any individual (including an especially sensitive individual) may be exposed to 25 ppm of ammonia without experiencing other than mild health effects or a transitory odor. All of these dose-response concentrations are orders of magnitude higher than even the maximum predicted ammonia concentrations at Connor's residence.

Based on this analysis, conducted using currently accepted risk assessment techniques, we can conclude that Connor's exposure to ammonia was well below a toxicological threshold. In the context of causation, ammonia could not have caused any of the claimed health effects alleged by Lewis et al. (2000).

CONCLUSIONS

Scientific criteria and methods exist for evaluating the alleged links between exposure to a chemical or microbiological agent and putative adverse health effects. When these rigorous methods are applied to claims reported in the media, it is found that the claims fail to demonstrate causation.

ACKNOWLEDGEMENTS

The research underlying this work was supported by an unrestricted grant from Synagro Technologies, Inc. Ammonia mass balance work was performed by Charles Henry, P.E., Ph.D, University of Washington.; air dispersion modeling was performed by Gale Hoffnagle, CCM, TRC Environmental Corporation; ammonia risk assessment was performed by Barbara Beck, Ph.D., DABT, Gradient Corporation; and differential diagnosis for Shayne Connor was performed by G.J.Walker Smith, M.D., Min-Vermont Pathology, P.C. Copies of the detailed reports written by these scientists are available from Synagro.

REFERENCES

Adamsen, F. & Sabey, B. 1987. Ammonia volatilization from liquid digested sewage sludge as affected by placement in the soil. Soil Sci. Soc. Am. J. 51:1080-1082.

Agency for Toxic Substances and Disease Registry (ATSDR) 1990. Toxicolgical Profile for Ammonia. Prepared for US Public Health Service by Syracuse Research Corp. CRC Press, Inc.

American Industrial Hygiene Association (AIHA) 1996. Emergency Response Planning Guidelines. AIHA Press.

American Pubic Health Association (APHA) et al. 1998. Standard Methods for the Examination of Water and Wastewater. 20th Ed.

Beauchamp, E. G., Kidd, G.E., Thurtell, G. 1978. Ammonia volatilization from sewage sludge applied in the field. Jour. Environ. Qual. 7:141-146.

Brooks, G.F., Butel, J.S., and Morse, S.A. 2001. *Medical Microbiology*. 22nd Ed. Lange Medical Books, New York.

Pennsylvania Department of Environmental Protection (DEP). 2000. Sampling at mountain top site.
http://www.dep.state.pa.us/dep/biosolids/mountaintop/SamplResults.htm.

Doll, R.D. 1984. Occupational cancer: Problems in interpreting human evidence. Ann. Occup. Hygiene. 28:291-305.

Donovan, W. & Logan, 1983. Factors affecting ammonia volatilization from sewage sludge applied to soil in a laboratory study. J. Environ. Qual. 12:484-590.

Dorn, C.R., Reddy, C.S., Lamphere, D.N. et al. 1985. Municipal sewage sludge application on Ohio farms: Health Effects. Environ. Res. 38:332-359.

Dumontet, S. Scopa, A., Kerje, S. and Krovacek, K. 2001. The importance of pathogenic organisms in sewage and sewage sludge. Jour. AWMA. 61:848-860.

Environmental Protection Agency (EPA) 2000. Integrated Risk Information System. Ammonia. http://www.epa.gov/iris.

Environmental Protection Agency (EPA) 1999. Control of Pathogens and Vector Attraction in Sewage Sludge. EPA/625/R-92/013.

Environmental Protection Agency (EPA) 1995a. A guide to the biosolids risk assessments for the 503 rule. EPA/832-B-93-005.

Environmental Protection Agency (EPA) 1995b. Pathogen Risk Assessment Methodology for Municipal Sewage Sludge Landfilling and Surface Disposal. EPA/00/R-95-016.

Environmental Protection Agency (EPA) 1989. Risk Assessment Guidance For Superfund, Part A. et seq. Office of Solid Waste and Emergency Response, Washington, DC.

Gibb, T. 2000. "A terrible waste gets long look" Pittsburgh Post –Gazette. June 11, 2000.

Haas, C.N., Rose, J.B., and Gerba, C.P, 1999. *Quantitative Microbial Risk Assessment.* Wiley, New York.

Haug, R.T. 1993. *The Practical Handbook of Compost Engineering*, CRC Press, Boca Raton, FL.

Haug, R.T. 2000. Affidavit of Dr. R.T. Haug in *Marshall et al. v. Synagro et al.*, October 30, 2000.

Harrison, E.Z., McBride, M.B., and Bouldin, D.R. 1999. The Case for Caution. Cornell Waste Management Institute.

Hill, B.A. 1965. The environment and disease: Association or causation? Proc. R. Soc. Med. 295:7-12.

Kolluru, R., Bartell, S., Pitblado, R., Stricoff, S. 1996. *Risk Assessment and Management Handbook.* McGraw Hill, New York.

Lewis, D.L., Shepherd, S., Gattie, D.K., Sanchez, S., and Novak, M. 2000. Enhanced susceptibility to infection from exposure to gases emitted by sewage sludge: a case study. Proc. Biosolids Management in the 21st Century. Univ. of MD, College Park, MD.

Lewis, D.L. 2001. Expert report of David L.Lewis, Ph.D. http://members.ad.com/LewisDaveL

Lighthart, B. and Shaffer, B.T. 1995. Airborne bacteria in the atmospheric surface layer: temporal distribution above a grass seed field. Appl. Environ. Microbiol. 61:1492-1496.

Lillienfeld, D.E. & Stolley, P.D. 1994. *Foundations of Epidemiology*. Oxford University Press.

Mahon, C.R. and Manuselis, G. 2000. *Textbook of Diagnostic Microbiology*. 2nd Ed. Saunders, Philadelphia.

National Institute for Occupational Safety and Health (NIOSH) 1999. Bio-solids Land Application Process, LeSourdesville, OH. HETA 98-0118-2748.

National Academy of Sciences (NAS)/National Research Council. 1983. *Risk Assessment in the Federal Government.* National Academy Press, Washington, DC.

Patrick, D.R. (Ed). *Toxic Air Pollution Handbook.* Van Nostrand Reinhold. New York.

Pillai, S.D., Widmer, K.W., Dowd, S.E., and Ricke, S.C. 1996. Occurrence of airborne bacteria and pathogen indicators during land application of sewage sludge. Appl. Environ. Microbiology. 62:296-299.

Snyder, D. and Kunkle, F. 2001. "Health Fears over Sludge Spur Quest for Controls". Washington Post, August 6, 2001.

Straub, T.M., Pepper, I.L., and Gerba, C.P. 1993. Hazards from pathogenic microorganisms in land-disposed sewage sludge. Revs. Environ. Contam. Toxicol. 132:55-91.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OCT 31 2002

Mr. Robert W. Varney
Regional Administrator
U.S. EPA, Region 1
John F. Kennedy Federal Building
One Congress Street, Suite 1100
Boston, MA 02114

Dear Mr. Varney:

The National Research Council of the National Academy of Science (NAS) completed an 18-month study and issued a report in July 2002 entitled *"Biosolids Applied to Land: Advancing Standards and Practices."* The U.S. Environmental Protection Agency (EPA) requested this study to assist the Agency in evaluating regulatory requirements and non-regulatory measures with respect to land application of biosolids. This is to advise you of our plan to respond to the NAS report and our advice regarding biosolids program implementation as the response plan is developed and implemented.

The overarching findings of the report concluded that there is no documented scientific evidence that the Part 503 rule has failed to protect public health, but there is persistent uncertainty on the potential for adverse health effects. The findings went on to say that, in the light of recent scientific advances, additional studies should be conducted and risk assessments performed to update the scientific basis of the rule.

The Agency recognizes the Academy for the quality of the report. EPA will formally announce in the Federal Register and solicit public comment on a proposed plan of action in response to the report by April 2003. Based on public comments and other relevant information, we will publish a final action plan in the Federal Register in January 2004. Meanwhile, relevant research is currently underway and additional resources will be dedicated to the action plan prior to January 2004. This process will provide an opportunity for public participation along the way.

In light of the recent NAS report's findings and recommendations and a stream of questions that have been raised by States, local governments, and concerned citizens since the release of the report, the guidance outlined below is offered:

- We recommend that biosolids continue to be managed in full compliance with the Part 503 rule. We agree with the NAS and their conclusions regarding the need for additional studies on the potential effects of biosolids. As noted above, we are committed to conduct additional research on this subject and take appropriate action based upon that work.

- We believe that pursuant to Part 503, it is a matter of local government choice whether their biosolids are land applied, landfilled or incinerated and that the report does not affect the viability of any of these options.

- We support the activities of the National Biosolids Partnership that are leading to the adoption of voluntary Environmental Management Systems (EMS) for biosolids. Wastewater treatment works with EMS's actively involve the public in setting EMS goals and will undergo independent third party audits of their programs after they become established. While adoption of EMS programs is not a substitute for oversight and enforcement, it improves biosolids management practices, including the control of odors.

- We recommend that biosolids management processes be reviewed during normal State or Federal inspections at wastewater treatment facilities. Violations of the Part 503 rule should be addressed through appropriate administrative enforcement.

The sound management of the biosolids program will continue to be an important element of the National Water Program. A full copy of the NAS report is available on EPA's website at http://www.epa.gov/waterscience/biosolids/nas/complete.pdf. If you have any questions, please contact us or have your staff contact Dr. Alan Rubin at 202-566-1125. We look forward to working with you as the action plan is developed.

Sincerely,

G. Tracy Mehan, III
Assistant Administrator
Office of Water

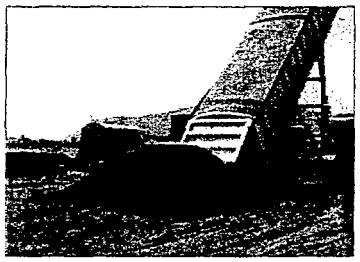
Paul Gilman
Assistant Administrator
Office of Research and Development

IDENTICAL LETTERS SENT TO:
Regional Administrators, Regions I-X
State Commissioners (All States)

Biosolids Applied to Land: Advancing Standards and Practices

Board on Environmental Studies and Toxicology

For several decades the wastewater treatment industry has recycled sewage sludge by applying a treated form of it (often referred to as biosolids) to agricultural or other lands in order to improve the properties of the soil. The practice offers an alternative to disposal options such as landfilling or incineration, and its use has increased since disposal of sewage sludge in oceans was prohibited in 1992. Today, roughly 60% of the 5.6 million dry tons of sewage sludge disposed of annually is used for land application in the United States.



Biosolids are complex mixtures that can contain pollutants from household, commercial and industrial wastewaters with organic contaminants (such as pharmaceuticals), inorganic contaminants (metals and trace elements) and pathogens (bacteria, viruses and parasites). Depending on the extent of treatment, biosolids may be applied on areas with limited public exposure such as farms, or with more treatment on public sites such as parks, golf courses, lawns and home gardens.

In 1993, EPA established a regulation governing land application of sewage sludge under the Clean Water Act with the intent to protect public health and the environment from reasonably anticipated adverse effects. The regulation (Code of Federal Regulations Title 40, Part 503, commonly referred to as the Part 503 rule) sets chemical pollutant limits, operational standards designed to reduce pathogens and the attraction of disease vectors (such as insects), and management practices.

Public health concerns regarding the use of biosolids are growing, especially from citizens living near application sites. The EPA asked the National Academies to convene a committee to conduct an independent evaluation of the technical methods and approaches used to establish the chemical and pathogen standards for biosolids, focusing specifically on human health protection. The committee was not asked to determine whether EPA should continue to promote land application of biosolids or to judge the adequacy of the individual standards in protecting human health, but rather to reassess the scientific basis of the Part 503 rule.

Overarching Recommendations

There is uncertainty about the potential for adverse human health effects from exposure to biosolids. To assure the public and to protect public health, there is a need to update the scientific basis of the Part 503 rule. The committee identified several data gaps and issues in management practices that should be addressed including:

- *A lack of exposure and health information on exposed populations.* The committee recommends implementing human health studies, including short-term investigations of unusual episodes of release, exposure, or disease, and large-scale preplanned studies of exposures and their association, if any, with disease.
- *Reliance on outdated risk-assessment methods.* Since 1993 when the rule was established, risk-assessment methods have advanced significantly. The committee recommends that new risk assessments be used to update the scientific basis of the chemical limits and the regulatory criteria for pathogens.
- *Reliance on outdated characterization of sewage sludges.* Changes in treatment processes and chemical uses over the last decade have changed the composition of sewage sludges. The committee recommends a new national survey of chemicals and pathogens in sewage sludges and a review of management practices to ensure that risk assessment principles are put into practice.
- *Inadequate programs to ensure compliance with biosolids regulation.* EPA should expand its oversight activities to include procedures to 1) assess the reliability of biosolids treatment processes and effectiveness of management practices, 2) monitor compliance with chemical and pathogen standards, 3) conduct environmental hazard surveillance, and 4) study human exposures and health.
- *Lack of resources devoted to EPA's biosolids program.* More funding and staff resources are needed to implement the recommendations in this report. The committee also recommends that EPA delegate authority to more states to administer the federal biosolids regulation.

Health Effects Recommendations

There are anecdotal reports attributing adverse health effects to biosolids exposures, ranging from relatively mild irritant and allergic reactions to severe and chronic health outcomes. The Committee recommends that the EPA promote and support studies of exposed populations in order to document whether any health effects can be linked to biosolids exposure through the following types of studies:

- Studies in response to unusual exposures and unusual occurrences of disease.

- Preplanned assessment studies to characterize exposures of workers and the general public who come into contact with biosolids.
- Complete epidemiological studies, for example, evaluating health effects in a group of biosolids appliers.

Chemical Standards Recommendations

In developing the 1993 Part 503 rule, the EPA relied heavily on its 1988-1989 National Sewage Sludge Survey to identify chemicals to regulate, selecting 9 inorganic chemicals (arsenic, cadmium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc). Risk assessments were conducted on each chemical to establish acceptable concentration limits.

Since 1993, new chemicals of concern have been identified, such as organic compounds used as flame retardants (i.e., brominated diphenyl ethers), pharmaceuticals and odorants. Chemicals eliminated in earlier selection processes because of data gaps might now be reevaluated in light of new data.

To set the 1993 limits for the regulated chemicals, the EPA considered 14 major exposure pathways, nine of which involve exposure to humans. EPA elected to estimate human exposure based on a theoretical, highly exposed individual (HEI), and gave no consideration to aggregate exposure, but rather evaluated each exposure pathway independently.

The Committee made the following recommendations regarding chemical standards:

- A new national survey of chemicals in sewage sludge should be conducted. Data from the survey should be used to determine whether additional chemicals should be considered for regulation.
- Using current risk-assessment practices, EPA should reassess standards for regulated chemicals. Because of the diversity of exposed populations and environmental conditions in the United States, it is important that nationwide chemical regulations be based on the full range of exposure conditions that might occur.
- Conceptual site models should be used to identify major and minor exposure pathways.
- A hypothetical individual with reasonable maximum exposure (RME, such as a farm family living adjacent to an application site), rather than an HEI, should be evaluated for each exposure pathway. If there is likely more than one pathway, exposures should be added across pathways.
- Representatives of stakeholders should be included in the risk-assessment process.

Pathogen Standards Recommendations

EPA considered a spectrum of bacteria, viruses, and parasites in setting its 1993 pathogen standards. No risk assessments were conducted to establish these standards. Instead, EPA established requirements to reduce pathogens by treatment or a combination of treatment and use restrictions. Given the variety of pathogens that have the potential to be present in biosolids, the committee supports this approach. However, the reliability of EPA's treatment techniques should be better documented using current pathogen detection technology, and more research is needed to verify that current management controls are adequate to maintain minimal exposure concentrations over an extended period of time.

The Committee recommends the following:

- EPA should conduct a national survey of pathogen occurrence in raw and treated sewage sludges.
- Quantitative microbial risk assessments (QMRAs) should be developed and used to establish regulatory criteria for pathogens in biosolids. QMRAs should include evaluation of all potential exposure pathways (e.g., transport of bioaerosols, runoff), and the possibility of secondary transmission of disease such as through person-to-person contact.
- EPA should foster development of standardized methods for measuring pathogens in biosolids and bioaerosols.
- EPA should promote research that uses improved pathogen detection technology to better establish the reliability of its prescribed pathogen treatment processes and biosolids-use controls to achieve and maintain minimal exposure over time.

Committee on Toxicants and Pathogens in Biosolids Applied to Land: Thomas Burke (*Chair*), Johns Hopkins University, **Lawrence R. Curtis**, Oregon State University, **Charles N. Haas**, Drexel University, **Ellen Z. Harrison**, Cornell University, **William E. Halperin**, New Jersey Medical School, **John B. Kaneene** Michigan State University, **Greg Kester**, Wisconsin Department of Natural Resources, **Stephen P. McGrath**, Institute for Arable Crops Research, **Thomas E. McKone**, University of California, **Ian L. Pepper** University of Arizona, **Suresh D. Pillai**, Texas A&M University, **Frederick G. Pohland**, University of Pittsburgh, **Robert S. Reimers**, Tulane University, **Rosalind A. Schoof**, Gradient Corporation, **Donald L. Sparks**, University of Delaware, **Robert C. Spear**, University of California at Berkeley, **Susan Martel** (Study Director), the National Academies' Board on Environmental Studies and Toxicolgy.

Biosolids Applied to Land: Advancing Standards and Practices is available from the National Academy Press, 2101 Constitution Avenue, N.W., Washington, DC 20055; (800) 624-6242 or (202) 334-3313, or http://www.nap.edu.

A TECHNICAL REVIEW OF:

"THE CASE FOR CAUTION

RECOMMENDATIONS FOR LAND APPLICATION OF SEWAGE SLUDGES

AND

AN APPRAISAL OF THE USEPA'S PART 503 REGULATIONS"

August 1997 Working Paper
Cornell Waste Management Institute

NOVEMBER 1997
[Includes changes based on EPA review]

New York State Department of Environmental Conservation
Division of Solid & Hazardous Materials

FOREWORD

This report contains our review of the August 1997 Cornell Waste Management Institute Working Paper titled "The Case For Caution: Recommendations For Land Application of Sewage Sludges and an Appraisal of the United States Environmental Protection Agency's (USEPA) Part 503 Sludge Rules" by the Division of Solid & Hazardous Materials in the New York State Department of Environmental Conservation (NYSDEC). The Cornell Working Paper raises concerns regarding the federal risk assessment behind federal rule 40 CFR Part 503 governing the beneficial use of biosolids (sewage sludge) and states that the federal regulations are not protective of human health and the environment.

In New York State, sewage sludge, by statutory definition, is a solid waste. As a solid waste, this material is regulated by the NYSDEC's Division of Solid & Hazardous Materials under 6 NYCRR Part 360 (Part 360) Solid Waste Management Facilities. NYSDEC is currently in the process of updating the Part 360 regulations applicable to biosolids beneficial use to incorporate Part 503 criteria.

The Part 503 risk assessment is a work product of the USEPA, not the NYSDEC. NYSDEC has reviewed, in depth, the support documents for the USEPA risk assessment and believe the standards derived are protective of public health and the environment. This report presents information from the USEPA, USDA, and others in response to the Cornell Working Paper.

We welcome comments on this report. Comments may be sent to:

Norman H. Nosenchuck, P.E.
Director
Division of Solid & Hazardous Materials
New York State Department of Environmental Conservation
50 Wolf Road
Albany, New York 12233-7250

CONTENTS

SUMMARY

Biosolids (sewage sludge) is an inevitable end product of modern wastewater treatment. An estimated 5.8 million dry short tons of sewage sludge are produced each year in the United States and 360,000 dry short tons per year are produced in New York State. Land application of municipal biosolids has been practiced for its beneficial effects since that advent of modern wastewater management about 150 years ago. The nutrients and organic matter in treated biosolids resembles those in animal manure and organic composts.

If all the biosolids produced in the United States were agriculturally applied at agronomic rates, it would only satisfy the nitrogen needs of about 1.6 percent of the nation's cropland. In New York State, if all the biosolids were applied to agricultural lands in the State at agronomic rates, it would only utilize nine percent of the cropland in New York State. In reality, this number is more likely well below five percent of the cropland in the State because some treatment plants will not practice beneficial use due to economics or biosolids quality concerns; some biosolids products such as compost are used for landscaping instead of cropland; and products can and do move to out-of-State markets as well. Currently, in New York State, only 0.16 percent of the cropland in the State is needed for the biosolids currently being used in agriculture.

Biosolids are recognized as potentially harmful because of the chemical pollutants and the disease-causing agents they may contain. In 1977 and 1987, Congress amended section 405 of the Federal Water Pollution Control act to require USEPA to develop technical standards for sewage sludge use and disposal. In 1982 USEPA began the process of developing the federal rule. A risk assessment approach was used and pathways of exposure were developed and completed. In 1993 the final federal rule, 40 CFR Part 503, was published. The federal rule has been the subject of extensive peer review and is supported by the USDA, the National Research Council and many academic institutions.

Certain individuals at Cornell University have raised concerns with the federal risk assessment and do not believe the federal rule is protective of public health and the environment. USEPA and USDA have reviewed the concerns raised by these individuals at Cornell. Both USEPA and USDA believe the concerns raised are without scientific basis. Dr. Rubin of USEPA stated "I am dismayed to see the Report's conclusions on the efficacy of the land application of biosolids based on poor science or on hypotheses that have been shown to be incorrect many years ago. I expect conclusions on the impacts of biosolids and valid recommendations on biosolids land application to be based on up-to-date peer reviewed scientific hypotheses and well-designed field

trials. Sadly, I do not see this in the enclosed Report. I expect better of a University with an excellent reputation in the field of agricultural sciences."

This report is the result of a NYSDEC review of the August 1997 Cornell Working Paper titled "The Case For Caution - Recommendations For Land Application of Sewage Sludges And An Appraisal of The US EPA's Part 503 Sludge Rules." In essence, the response to the Cornell Working Paper concerns is as follows:

1. & 2. Allow pollutant loading to acceptable levels and no safety factors there are many safety factors built into the risk assessment through the use of conservative data, controlling pathways and policy decisions.

3. Multiple pathways of exposure and synergy - multiple pathways of exposure given the conservative assumptions in the Part 503 pathway assessment would protect a non-existent person. Synergy has not been seen with biosolids.

4. Cancer risk - a policy decision was made by USEPA since the risk was so low without regulation. Lower risk would have no effect on outcome of regulation.

5. Soil ingestion rate - the Part 503 risk assessment does consider lifetime soil ingestion. Other conservative factors also involved in this pathway.

6. Underestimates pollutant intake through food - no scientific basis for the degree of conservatism proposed.

7. RfD for arsenic - no current agreement on RfD for arsenic. Using lowest RfD with other conservative factors yeilds a standard below background soil levels.

8. Pollutants not regulated - organic pollutants are not found in large numbers in biosolids, those found are typically at low levels.

9. Ground and surface water - it is generally agreed that metals from biosolids do not readily move through the soil profile; management practices minimize potential surface water impacts.

10. Agricultural phytotoxicity - no scientific basis for concern raised.

11. Pathogen risks - no evidence that biosolids used under regulation controls pose a risk.

12. Ecological risks - assessed during risk assessment, new research will be considered.

13. Inadequate enforcement and oversight - USEPA and NYSDEC take their responsibilities seriously and enforce all biosolids regulations.

14. Labeling of sludge or sludge products - only makes sense if all products in the marketplace must similarly label their products.

INTRODUCTION

Biosolids (sewage sludge) is the highly organic material that results from the treatment of municipal wastewater. Biosolids contains nutrients and organic matter that are beneficial to soil and plants as a source of nutrients and as a soil conditioner. Biosolids may also pose risks to the public and the environment if not properly regulated due to pathogen and/or pollutant content.

The regulation of the beneficial use of biosolids on the federal level and in New York State has existed for more than 15 years. The land application of biosolids for nutrient value has occurred in this county and elsewhere in the world for decades. In New York State, we are not aware of any adverse human health or environmental impacts from the beneficial use of biosolids in compliance with State and federal regulations. Currently, in New York State, more than 50 percent of the biosolids generated are beneficial used through direct land application, as compost, lime, and as heat-dried products. These materials are used effectively by farmers, homeowners, landscapers, and others as nutrients and soil conditioners.

In New York State, the regulation of biosolids use facilities is found primarily in 6 NYCRR Part 360 Solid Waste Management Facilities (Part 360). Part 360 is a comprehensive permit-driven regulation. In New York State, all biosolids beneficial use is subject to a Part 360 permit and associated design, operational, and reporting criteria. The pollutant limits found in Part 360 are derived from federal rule and guidance available.

The last time the biosolids aspects of Part 360 were revised was 1988. The federal regulations governing the beneficial use of biosolids (40 CFR Part 503) were published in 1993. NYSDEC is currently in the process of incorporating Part 503 into Part 360. In some cases (pollutant limits, testing frequency, and others) NYSDEC is proposing to be more stringent than Part 503, providing additional safeguards for New York State's environment and public health.

The federal Part 503 rule is based on the risk assessment approach. The regulation took almost a decade to complete and has been subject to extensive peer review. For beneficial use, 14 potential pathways of exposure to a highly exposed individual were assessed. These pathways are outlined at the end of the Introduction.

The risk assessment and rulemaking effort for Part 503 can be broken down into 15 major steps, as follows (beginning in 1982):

1. An intra-agency sludge task force developed a comprehensive plan with

input from all impacted groups.

2. Identification of 200 pollutants and evaluation of their expected toxicity.

3. Selection of 50 pollutants for further study.

4. Initial identification of exposure pathways for each use or disposal practice.

5. Profile assessment and hazard indices developed for 50 pollutants.

6. Selection of pollutants for detailed risk assessment.

7. Risk assessment methodology review by the EPA Science Advisory Board.

8. Risk assessments for proposed Part 503 rule conducted.

9. Published proposed Part 503 for comment in 1989.

10. Risk assessments for final Part 503 rule revised based on comments; expert advisors continue reviews.

11. National Sewage Sludge Survey (NSSS) conducted.

12. Published NSSS results and proposed changes for final Part 503 rule for comment published.

13. Risk assessments for final Part 503 rule revised.

14. Internal EPA review of draft final Part 503 rule.

15. Published final Part 503 rule (February 19, 1993).

The federal Part.503 is protective of human health and the environment. The Cornell Waste Management Institute has raised concerns regarding the risk assessment and has recently published a document outlining their concerns titled "The Case for Caution: Recommendations for Land Application of Sewage Sludges and an Appraisal of the USEPA's Part 503 Regulations." This paper provided a response to their concerns.

Pathways of Exposure for Land Application Under Part 503

Pathway	Description of Highly Exposed Individual
1 . Biosolids Soil - Plant - Human	Human (except home gardener) lifetime ingestion of plants grown in biosolids-amended soil.
2. Biosolids Soil - Plant - Human	Human (home gardener) lifetime ingestion of plants in biosolids-amended soil.
3. Biosolids - Human	Human (child) ingesting biosolids.
4. Biosolids - Soil - Plant - Animal - Human	Human lifetime ingestion of animal products (animals raised on forage grown on biosolids amended soil).
5. Biosolids - Soil - Animal - Human	Human lifetime ingestion of animal products (animals ingest biosolids directly).
6. Biosolids - Soil - Plant- Animal	Animal lifetime ingestion of plants grown on biosolids-amended soil.
7. Biosolids - Soil - Animal	Animal lifetime ingestion of biosolids.
8. Biosolids - Soil - Plant	Plant toxicity due to taking up biosolids pollutants when grown in biosolids-amended soils.
9. Biosolids - Soil - Soil Organism	Soil organism ingesting biosolids/soil mixture.
10. Biosolids - Soil - Soil Organism - Soil Organism - Predator	Predator of soil organisms that have been exposed to biosolids-amended soils.
11. Biosolids - Soil - Airborne Dust- Human	Adult human lifetime inhalation of particles(dust) (e.g., tractor driver tilling a field).
12. Biosolids- Soil - Surface Water - Human	Human lifetime drinking surface water and ingesting fish containing pollutants in biosolids.
13. Biosolids - Soil - Air - Human	Human lifetime inhalation of pollutants in biosolids that volatilized to air.
14. Biosolids - Soil - Groundwater - Human	Human lifetime drinking well water containing pollutants from biosolids that leached from soil to groundwater.

RESPONSE TO CORNELL CONCERNS

The following responses were developed by NYSDEC to address the concerns found on Pages 15-33 of the Cornell Working Paper. These concerns relate to the federal risk assessment that forms the basis for federal 40 CFR Part 503 governing the beneficial use of biosolids. NYSDEC did not participate in the risk assessment process. Therefore, the responses below are based on information obtained from USEPA and others concerning the risk assessment.

Each of the responses below are brief. These subjects are worthy much more lengthy discussion, but brevity is useful to address all concerns in a reasonable fashion.

For those interested in more detail concerning the risk assessment, NYSDEC strongly suggests that the following documents be obtained and read:

"A Guide to the Biosolids Risk Assessments for the EPA Part 503 Rule," USEPA, EPA 832-B-93-005, September 1995.

"A Plain English Guide to the EPA Part 503 Biosolids Rule," USEPA, EPA/832/R-93/003, September 1994.

"Technical Support Document for Land Application of Sewage Sludge," USEPA, EPA 822/R-93-001a&b, Volumes I & II, November 1992.

There are many other documents and research papers from USDA and others that can also be reviewed.

Cornell Concern:

1. Allows pollution to reach maximum "acceptable" level;, and
2. No safety or uncertainty factors.

Brief Statement of Concern:

In establishing Part 503 regulations, the policy choice made is that pollutants can be added up to the level which represents some determination of the acceptable risk. No safety factor is applied, leaving no margin for error nor for future changes in determination of what levels represent an acceptable risk.

Response:

The biosolids risk assessment process involves selecting representative pathways by which humans, animals, and plants could be exposed to pollutants of concern that can be present in biosolids. Data on exposures associated with each pathway were combined with data on allowable doses of a pollutant to develop a limit for that pollutant.

Safety factors can be incorporated into a risk assessment process in many ways. Two of the basic methods are in the choice of data and another is to divide by a factor after a value is derived from the risk assessment process. For example, safety factors can be built into the risk assessment by choosing data or making assumptions that are conservative themselves, such as choosing the percentage of a person's diet from their own garden that represents only a tiny fraction of the population if any at all. Using conservative data and assumptions will lead to conservative results with hidden safety factors and therefore reduces or eliminates the need for the use of an arbitrary safety factor applied to the result of the risk assessment.

A second method cf adding a safety factor to a risk assessment is to take the results of the risk assessment and scaling down the acceptable level by a arbitrary amount or safety factor. This may be appropriate if the risk assessment uses data that is not conservative, such as using the average percentage of a person's diet that is derived from their own garden, or where there is great uncertainty in data or lack of data available.

The concern raised by the Cornell Working Paper implies that since the Part 503 risk assessment does not apply a safety factor to the results of the assessment that there is no safety in the results. This is not

true. EPA chose to use conservative data in the risk assessment instead of an arbitrary safety factor at the end. Therefore, NYSDEC believes the results are conservative and highly protective. EPA believes that the addition of a safety factor would result in standards that are so conservative that they may protect a non-existing person, one that could not possibly be exposed to the extent implied.

An examination of the 14 pathways of exposure evaluated and the data used in the Part 503 will outline how conservative the resultant standard is. For example, Pathway 2 evaluates human toxicity from plant ingestion from foods grown in their home garden. The basics of the pathway assessment are presented below for inorganics with an indication of the conservativeness of the data used.

Agricultural Pathway 2 (Human Toxicity from Plant Ingestion - Home Gardener)

Sewage Sludge -> Soil -> Plant -> Human

Highly Exposed Individual (the pathway is designed to protect this fictitious person):

The home gardener who grows a major portion of his or her diet in soil that has been amended with biosolids. The home gardener would have to continuously consume this portion of crops from the garden for 70 years and the soil would have to contain the maximum amount of pollutant allowed from biosolids applied.

*SAFETY FACTOR (CONSERVATIVE ASSUMPTION):

Very few individuals in the U.S. grow a major portion of their diet from their garden for their entire life. Estimated to be less then one percent of the population.

Risk Assessment Calculations:

$$RIA = (A - TBI)*1000 \qquad A = \frac{RfD \times BW}{RE}$$

Where:

RIA =Adjusted reference intake of pollutants in human beings -a number that indicates how much of the pollutant can be ingested by a person with minimal risk of adverse impact.

RfD = Oral reference does - the daily intake of a chemical, over an

entire lifetime, that appears to be without appreciable risk.

BW = Adult body weight.

TBI = Total background intake of pollutant from other sources.

RE = Relative effectiveness of ingestion exposure. Route of exposure (inhalation vs. ingestion) and exposure medium (water vs. food) affects effectiveness. RE = 1 is used in this risk assessment.

*SAFETY FACTORS (CONSERVATIVE ASSUMPTIONS):

RfD (Reference Dose) - The dose with no expected adverse impact is derived from human and animal studies and includes a safety factor ranging from 10 to 10,000 and is meant to protect sensitive members of the population.

RE (Relative Effectiveness) - RE is a factor that accounts for the differences in effectiveness due to exposure route and exposure medium. Using RE=1 assumes maximum effectiveness, even though ingestion through the diet may be less of a risk than other types of exposure to the pollutant or effectiveness may be reduced due to other factors.

$$RPc = \frac{RIA}{Sum\ (UCi * DCi * FCi)} \qquad (2)$$

Where:

RPc = Reference cumulative application rate of pollutant (kg pollutant/ha) - the acceptable amount of pollutant that can be applied to the soil.

RIA = Adjusted reference intake [see equation (1)].

UCi = Uptake response slope of pollutants in plant tissue for the food group.

DCi = Daily dietary consumption of the food group.

FCi = Fraction of food group produced on biosolids amended soil.

*SAFETY FACTORS (CONSERVATIVE ASSUMPTIONS):

UCi - Uptake of pollutants by plants - the risk assessment assumes a

linear response (the uptake of pollutant into the plant increases proportionally to the quantity of pollutant applied). In reality, for biosolids, the uptake of pollutant flattens out or plateaus as the concentration increases. Therefore, a linear assumption would overestimate the quantity of pollutant in the plant in the long term. Also, the use of high-metal content sewage sludge data, the assignment of a positive slope even if the study showed no slope or a negative slope, the inclusion of low pH studies, and the use of short-term studies in this calculation overestimates uptake.

FCi -Fraction of food produced on sewage sludge - amended soil in the home garden: the values used were conservative: 59% of the persons vegetables are grown in the garden (10% would be a more reasonable estimate), 37% of their potatoes are homegrown, and 0.4% of their flour and cereal. It would be difficult for any home gardener to attain these levels, especially in New York State given the limited growing season.

In summary, the individual risk assessment pathway analysis included the use of conservative assumption or built in safety factors which, in EPA's opinion, negated the need for an arbitrary safety factor or scaling factor applied to the standard derived. In some cases, EPA also made policy decisions that added additional safety including choosing a lower standard for lead and reducing the standard to equal 'the 99 percentile of national sludge quality, if the 99 percentile was a lower number. Also, the standard in Part 503 is equal to the lowest value found from the 14 pathways. This adds safety factors to all noncontrolling pathways.

Cornell Concern:

3. Evaluates each exposure pathway separate y not accounting for multiple pathways of exposure or synergy.

Brief Statement of Concern:

Where sludges are used, exposure to contaminants will come from a number of routes (e.g., eating sludged crops, ingesting sludged soil, drinking water which has received some sludge contaminants). Most risk assessments take this into account by adding exposures from different pathways, but the Part 503 risk assessment does not.

Response:

Multiple pathways of exposure - The Part 503 risk assessment is designed to protect a "Highly Exposed Individual" (HEI). The HEI is meant to possibly represent a real individual, albeit a very small fraction of the population, if the individual exists at all.

A hypothetical individual that is exposed to many pathways of exposure, given the criteria used in those pathways, is unlikely to exist. For example, the Cornell Working Paper sites the case of a child of a home gardener that drinks water from a well or eats animals impacted by sludge use. If we take only the first part of this scenario (the child of a home gardener), for this individual to exist the following criteria would have to be satisfied:

* The child eats 200 milligrams of undiluted biosolids every day for five years (0.8 lbs of soil) - in actuality since EPA could not agree on a factor to scale a lifetime exposure number to five years, the risk assessment protects for a lifetime of exposure (70 years at 200 milligrams per day = 11.3 lbs of soil). For lead, an even higher ingestion rate would be required, because a policy decision was made to lower the lead standard by 40%.

* The biosolids are not mixed with the soil at all.

* The biosolids pollutant levels are equal to the standards.

* The pollutants in biosolids obtained through ingestion of solids are as effective as by other means, such as drinking water (in many cases this is not true).

* The biosolids pollutant levels in the garden at all times are equal to the maximum allowable level.

* The child's parents produce 59% of their vegetables and 37% of their potatoes in their garden.

* The child grows up and as an adult is also a gardener who produces the majority of his/her vegetable in his/her own garden, and the garden contains pollutant levels at the maximum allowed at all times. For the garden pathway, 70 years of exposure are assumed.

* The conservative plant uptake levels, effectiveness, and other assumptions are valid.

Given these criteria, the probability that this individual could exist is very low. The probability would drop even more if the full scenario outlined in the Cornell Working Paper is outlined. Synergistic (additive or more than additive) negative effects - According to EPA, the only evidence of synergy has been observed in soil freshly amended with metal salts (not biosolids). EPA is not aware of any evidence to suggest that synergy has occurred even in pot studies where metal-rich biosolids were used as the soil amendment.

Actually, there is evidence of positive interactive effects from biosolids metals. When biosolids are used as a source of fertilizer, there is a built-in protection for people who eat crops that may accumulate metals, including cadmium. This is because invariably biosolids also contain iron, calcium, and zinc, which are absorbed into the edible portion of the plant. The presence of these other three substances in the crop consumed reduces the potential for cadmium absorption into a person's intestines and body, and hence reduces the potential health risk from cadmium.

Cornell Concern:

4. Calculates cancer risk of 1-in-10,000 vs. 1-in-1,000,000.

Brief Statement of Concern:

Standards for carcinogens based on a risk assessment depend on what rate of increased cancer is considered acceptable. Values between one excess cancer in 10,000 to 1,000,000 people are typically used. A 1-in-10,000 risk was used in the Part 503 risk assessment.

Response:

First, cancer risk assessment in Part 503 applies to the organics, not the metals. For.Yart 503, metals were considered non-carcinogens and metals limits were based on threshold limits.

The EPA made a policy decision to choose a cancer risk level of 1-in-10,000 in Part 503. The reason for the choice of this risk level was the result of an aggregate risk assessment performed by EPA. This assessment did not show a significant carcinogenic risk to the population as a whole from biosolids. EPA estimated that, even without any federal rule, the risk from biosolids use could have contributed to 0.9 to 5 cancer cases annually (equivalent to 0.004 in 1,000,000 to 0.02 in 1,000,000). Since the risk was so low in the absence of regulations,

EPA chose a risk level of 1-in-10,000.

The risk level applies to the highly exposed individual, not the population as a whole. The population as a whole is exposed to a risk level orders of magnitude lower.

If a risk value of 1-in-1,000,000 had been used in Part 503 instead of 1-in-10,000 for organics it would have no affect on the standards. The Part 503 risk assessment deleted regulation of an organic pollutant in the rule if at least one of the following criteria were met:

* The pollutant has been banned or restricted for use in the United States, or is no longer manufactured for use in the United States.

* The pollutant is not present in biosolids at significant frequencies of detection (i.e., five percent) based on data gathered in a national sludge quality survey.

* The limit for the pollutant identified in the biosolids risk assessment is not expected to be exceeded in biosolids that are used or disposed, based on data from the national sludge survey.

Even if a risk level of 1-in-1,000,000 is used, the organics evaluated would still be deleted because one of the three criteria were satisfied.

Cornell Concern:

5. Soil ingestion rate.

Brief Statement of Concern:

Part 503 uses 200~mg/day soil ingestion rate for children in Pathway 3. This is not sufficient for children and does not account for adult exposure.

Response:

The soil ingestion rate used in Part 503 (200 mg/day) is based on a 1989 EPA directive from the Office of Solid Waste and Emergency Response recommending this value for the children at highest risk. This value may not be high enough to govern an unsupervised pica child that has hand to mouth tendencies, but EPA believes that parents will take

actions to reduce soil ingestion by these children. Also, in New York State, potential exposure of children to soil is reduced due to the climate.

Also, for one pollutant of particular concern to children, lead, EPA made a policy decision to reduce the lead standard. The risk assessment produced a standard of 500 ppm, but EPA chose to reduce the standard to 300 ppm. In addition, NYSDEC is proposing a cadmium standard of 21 ppm instead of the 39 ppm standard in Part 503 which adds safety for child exposure.

The Pathway assessment did consider lifetime consumption of soil. As discussed earlier, EPA attempted to quantify an exposure duration adjustment factor that would account for the fact that the child ingests for five years, but the reference dose is for a lifetime of exposure (70 years). The agency was not able to agree on an exposure adjustment so a lifetime exposure was used. Therefore, it is assumed 200 mg of soil are ingested each day for 70 years (11.3 lbs of soil).

Cornell Concern:

6. Underestimates pollutant intake through food:
   a. Assesses diet very low in vegetables.
   b. Very low plant uptake coefficients.
   c. Averages are not applicable to particular site or crop.
   d. Cadmium levels under different assumptions.

Brief Statement of Concern:

a. Americans are eating more vegetables than the amount used in calculating the Part 503 standards. USDA recommendations are far more than that amount.

b. The Part 503 rules are based on very low uptake coefficients which are lower than those of many sites and soils.

c. Using averages for crop uptake is not a valid approach.

d. Application of different data and assumptions regarding diet and uptake coefficient results in acceptable cumulative loadings for cadmium that differ by a factor of 80.

Response:

a. Vegetables in the diet - as described under concerns #1 and #2, pathway 2 involves the home gardener eating a major portion of their diet from the garden. An assessment of this pathway includes an assessment of the individual's consumption of food groups. Pathway 1 involving a human (not a home gardener) who ingests plants grown in sludge amended soil also needs to use data on consumption of food in various food groups.

As outlined under concerns #1 and #2 the calculations for pathway 2 include a number of data values. Some of the values used are conservative and some are considered average. Using this combination of values, a conservative result is obtained. If only very conservative values are used for all inputs to the equations, and unrealistic result will be derived (i.e., the standard is lower than the content of uncontaminated soil, etc.).

To determine the dietary consumption (DC) for pathways 1 and 2, EPA estimated the lifetime average daily food intake based on surveys/ studies of actual intake, not USDA recommended intake as suggested by the Cornell Working Paper. EPA considers the DC values used as an average value, not a conservative value since it is the average consumption over a lifetime. However, given that many other conservative values are used in the calculations, EPA believes the values used are appropriate.

Also, it should be noted that pathway 1 or 2 did not lead to values that dictated the regulatory standard for any inorganic pollutant (they were never the controlling pathways). Therefore, there is added safety given to these pathways due to the imposition of lower standards from other pathways. For example, the cadmium standard is less than one-third of the value allowed under pathway 1 and 2. In addition, NYSDEC is proposing to utilize the USDA recommendation for cadmium (21 ppm) instead of the P4rt 503 standard (39 ppm), which would further reduce any potential risk in New York State.

The Cornell Working Paper also states that states with high populations, such as New York State, may ultimately have a much higher proportion of sludged agricultural land. This is not necessarily true. New York State is a good example. New York City (City) generates more than 30 percent of the biosolids generated in the State and more than 90 percent of the City's biosolids are beneficially used. However, none of the agricultural land in New York State contains biosolids from the City at this time. The City ships biosolids to more than a dozen states for use

as fertilizer supplements. The discussion in the Working Paper also leaves the impression that food crops (crops consumed directly by humans) are a major market for biosolids. This is not the case. Although biosolids can be applied to food crops under Part 503, many biosolids (such as compost) products are used for landscaping or other non-food crop uses.

b&c. Very low plant uptake coefficients and averages are not applicable to particular site or crop - Prior to calculating plant uptake slopes for pollutants in the risk assessment, EPA reviewed, corrected, expanded, and ranked the data from numerous studies on plant uptake (see Box 1).

Data from Type A (field) studies were used whenever available for the risk assessment because they best represent conditions being regulated. Nonetheless, for certain categories of studies other types of data were used. Data from Type B biosolids pot studies were used for mercury and selenium. Type C data were used for arsenic for all but "leafy vegetables," for which Type A data were used.

Box 1
EPA Plant Uptake Data Ranking Classification

Type A:	Data from studies conducted in fields where biosolids had been applied.
Type B:	Data from all other studies conducted with biosolids (i.e., field studies using biosolids spiked with additional metals; greenhouse studies using plants grown in biosolids in pots).
Type C:	Data from all other non-biosolids metals studies in the field or greenhouse (e.g., studies using metal salts or soils contaminated or geochemically enriched from sources other than biosolids.

The plant uptake slope, or response, for each study was then calculated. For studies with multiple application rates and tissue concentrations, the linear regression statistical method was used to calculate the plant uptake slope. If the calculated uptake slope was negative or zero, a default slope of 0.001 was used. It is quite reasonable that the uptake slope of metals may be negative (i.e., that lower amounts of metals are obtained from soil by plants after biosolids are added to soils, even though the biosolids also contain the same metals). A negative slope would result from the strong binding surfaces in the biosolids matrix, which hold metals already present in soils and reduce their availability for plant uptake. The use of a minimum plant uptake slope was required for calculating geometric means. Therefore, the conservative assumption

of a 0.001 minimum uptake slope allowed negative uptake data to be included in the risk assessment data set, even though that assumption caused the uptake slopes for the pollutants analyzed to be overestimated and the pollutant limits to be conservative.

Plants types were assigned to food groups (garden fruits, grains and cereals, leafy vegetables, legumes, potatoes, and root vegetables), and the uptake slope for each food group was calculated for each pollutant using the geometric mean (average) of the uptake slopes already calculated for individual studies in the food group.

A combination of conservative (very low probability of occurrence) and less conservative (low to average probability of occurrence) assumptions were used to calculate uptake coefficient (UC) values in the biosolids land application risk assessment. This UC value is an overestimation of actual plant uptake because several of the key assumptions and data sets used were conservative, including: the assumption that plant response slope is linear; the use of high-metal-content biosolids data; and the use of short-term data from field studies (1 or 2 years after application), in which equilibrium had not been attained (these and other conservative assumptions used are explained below). Because of this conservatism, the geometric mean, rather then the more conservative arithmetic mean, was used to statistically represent the log normal distribution of UC data because the geometric mean provides a better estimate of central tendency for data with this type of distribution (i.e., by using the geometric mean, UC reflects median data).

Conservative criteria used in the uptake calculations:

Minimum Plant Uptake Value Used. A minimum value of 0.001 mg/kg for plant uptake of a pollutant was assumed, even when data indicated no increase in pollutant concentration in plants or when uptake was negative. This assumption of minimum plant uptake is conservative and results in an overestimation of UC, because lower UC values would have resulted if the actual values were used.

Use of Linear Response Slope. Another conservative assumption in calculating the value of the UC parameter involved the use of a linear response slope to represent plant uptake of metals. Briefly, numerous field studies indicate that plant uptake of metals is curvilinear (i.e., increases up to a point and then levels off, or plateaus, even if more pollutant is added to the soil), given the ability of biosolids to bind pollutants in biosolids/soil mixtures. Nevertheless, the biosolids risk assessment conservatively assumed a linear response (i.e., uptake continues to increase indefinitely).

Inclusion of Acidic pH Data. The UC data included results from field studies that represented both low pH (acidic) and neutral soil conditions, even though low pH is unlikely to occur for very long (certainly not for the 70-year lifetime exposure of the HEI) because gardeners probably would quickly correct the soil pH (e.g., add lime) to improve plant health. In addition, increases in the solubility of two metals, aluminum and manganese, will cause injury in most plant species in low pH soil conditions, even if no additional metals are added (e.g., from biosolids). Thus, including data for low pH conditions overestimates UC values. Nevertheless, because acidic soil conditions can periodically occur, and because data show that low pH can result in phytotoxicity, plant response under acid soil conditions was included in the data set. Forty percent of the data used to calculate UC values was based on studies with a pH of less than 6.0. Using these low pH data, a garden would be strongly acidic for approximately 30 of the 70 years of HEI exposure for Pathway 2, an unlikely occurrence.

In addition, in the case of cadmium, if low pH conditions are not corrected (allowing for high cadmium uptake by plants), the presence of zinc (in a ratio less than or equal of 0.015 cadmium to zinc), which also is taken up by plants under low pH but otherwise normal soil conditions, will lower cadmium risks for two reasons. First, zinc is known to reduce the phytoavailability of cadmium for plant uptake. Second, the reduction in plant yield resulting from zinc toxicity would reduce potential consumption of crops containing high levels of cadmium.

Use of Short-Term Data to Predict Long-term Pollutant Uptake.

Bioavailability of metals for plant uptake is highest in the first year after land application of the biosolids. The lifetime UC values are based primarily on short-term data. Use of these early-year data causes overestimation of long-term UC values.

Impact of Combining Conservative and Less Conservative Factors to Calculate UC. Combining the conservative factors discussed above for UC (e.g., the 0.001~bounding estimate, linearity, short-term data, and acid pH systems) with one or two less conservative factors (e.g., the geometric mean) to estimate the UC resulted in a calculated value for UC that was greater than the actual UC and, hence, overestimates risk in exposure pathways that use this parameter.

d. Cadmium levels under different assumptions - the Cornell Working Paper indicates that the use of different data and assumptions in the risk assessment will lead to different results (standards). This is certainly true, but EPA believes that the data and assumptions used in the Part 503 are appropriate and that the results are conservative and

protective of public health and the environment.

As discussed previously, a risk assessment involves the use of many data points. If all data points used are very conservative, the resultant standard may be unrealistic. An example of this problem is illustrated by the discussion in the Cornell Working Paper. The value for cadmium under the Monte Carlo analysis is 1.5 kg/ha indicating that any value above this level is not protective. 1.5 kg/ha equates to a soil concentration in the plow layer of about 0.75 ppm. Uncontaminated agricultural soil can exceed this level naturally. Also, the Cornell recommended maximum soil level found in Table 10 (2 ppm) is more than twice this level. Therefore, Cornell's own recommendation and some uncontaminated soils would exceed this "safe" level.

Cornell Concern:

7. RfD for arsenic of 0.0008 mg/kg/day vs. 0.0003 or less.

Brief Statement of Concern:

The reference dose (RfD), or daily exposure over a lifetime without appreciable risk, used by Part 503 for arsenic was 0.0008 mg/kg/day. There is uncertainty concerning the arsenic RfD and a lower level, such as 0.0003 should be used.

Response:

There is not a clear consensus among EPA scientists on the appropriate oral RfD for arsenic. EPA elected to use a less conservative value, 0.0008 mg/kg-day to use in the risk assessment, because most of the assumptions and values used in the pathway calculations are conservative as well as the low probability of continuous exposure from this source as compared to other sources such as drinking water.

If an Rfd of 0.0003 is used with the other conservative values used in the pathway 3 calculations yields an arsenic standard of 1.5 ppm dry weight basis. This standard would be overly conservative given that uncontaminated background soil often exceeds this value. This arsenic standard would also yield a soil level below the recommended values found in the Cornell Working Paper.

Cornell Concern:

8. Many pollutants not regulated or monitored.
   a. Pollutants present in less than 10% of sludges not considered.
   b Pollutants with insufficient data.
   c. Synthetic organic chemicals.
   d. Radioactivity.

Brief Statement of Concern:

a. A wide variety of contaminants have been found in sludges. Part 503 regulates only 9. While most sludges do not have high levels of nonregulated contaminants, without testing, a user has no way of knowing what unregulated sludge contaminants are present.

b. EPA determined that data for some pollutants were insufficient to perform a risk assessment and thus develop standards. The risks posed by some of these suggest a need for further study and regulation.

c. Current US rules contain no standards or testing requirements for organic chemicals. Standards for coplanar PCBs, dioxins, and furans are proposed for future development by the EPA. A number of synthetic organic detergent additives are found in high levels in sludges and are regulated in some European countries.

d. Radioactivity is not addresses in Part 503 and little is know about the extent to which sewage sludges are contaminated with radioactivity.

Response:

a. b.

& c. Organic pollutants - Part 503 does not require monitoring for organic pollutants due to their low occurrence in biosolids and due to other criteria. The potential for significant concentrations of organics and metals in biosolids has been reduced significantly due to the implementation of pretreatment programs at the federal, State, and local level. The State of Vermont recently sampled virtually all (74 of 76) of the municipal wastewater treatment facilities in the State and conducted extensive analyses. According to the Vermont report, the presence of organic compounds appeared to be negligible. An organic detection rate of less than three percent was found with concentrations detected typically less than one part per million. The majority of

detections were components of commonly used household products and were not indicative of industrial or commercial discharges. The National Sewage Sludge Survey conducted by EPA also found a low occurrence of organic compounds.

NYSDEC has proposed to require analyses of biosolids for inorganic and organic pollutants as a part of the permit application for beneficial use. This will provide additional information for each biosolids source in New York State and will indicate if there are any pollutants of concern with a particular biosolids.

d. Radioactivity - There are three general sources of radiation: from a natural origin, from a natural origin but affected by human activities, and from a manmade origin. Natural sources include radiation from outer space, radiation from materials in the ground, and others. Enhanced natural sources includes human activities that increase exposure such as frequent flying (comic radiation), people living in stone or brick houses, and people living in areas where radon is prevalent. Manmade radiation sources include medical x-rays, smoke detectors, and others. Regulatory responsibility for radioactive material in the United States is shared by federal, State and local agencies. At the federal level the Nuclear Regulatory Commission, EPA, the U. S. Department of Energy, the U.S. Department of Transportation, and the Department of Health and Human Services all have a role in the regulation of radioactive materials.

EPA evaluated radioactivity in sewage sludge samples analyzed in the 1980s. Any radioactive content found was not enough to produce a significant dose when land applied. In addition, in 1995, the Association of Metropolitan Sewerage Agencies, (AMSA) undertook a extensive investigation of radiation levels in biosolids across the United States. The radioactive substances found were of the type of concentration typically found in the environment.

Cornell Concern:

9. Ground and surface water calculations assume large dilution/attenuation,.

   a. leachate diluted/attenuated before reaching well.

   b. only 0.24% of the model watershed receives sludge.

Brief Statement of Concern:

In assuming that only a tiny fraction of the watershed is sludged, the

Part 503 risk assessment fails to assess impacts on smaller bodies of water.

Response:

a. Leachate reaching wells - the concerns raised in the Cornell Working Paper can be broken down roughly into three issues: the groundwater modeling conducted by EPA, recent research concerning leaching of metals, and the review of existing research on soil metal content.

Groundwater modeling under the Part 503 risk assessment - the Cornell Working Paper raises a concern about the pollutant concentration that is assumed to reach a well. The risk assessment for groundwater impact involved a multi-step process to determine standards that would protect a human from drinking water from wells containing pollutants leaching to ground water. This includes preparing a mass balance to determine pollutant removal from erosion, leaching, volatilization, and degradation. The amount of pollutant movement to groundwater was determined by two mathematical models. As discussed below, due to the nature of biosolids, the movement of pollutants to groundwater under the federal regulations is not expected. Also, since the groundwater pathway did not dictate the standard (another pathway such as child ingestion was more controlling) there is a built in safety factor of at least 64 fold included in the regulatory standard.

Recent research concerning leaching of metals - the Cornell working paper states "The generally-held belief that metals in sludges cannot readily leach has been called into question by recent data (Camobreo, et al. 1996; Richards, et al. 1997)." The November 1996 paper referenced in this section summarizes a laboratory research study conducted by Cornell University involving the adding of metals to soil columns and the collection of the leachate from the base of the columns. In this study, soluble metal salts were used, not biosolids. It has been stated by EPA, USDA and others that metals in sewage sludge are less available that soluble meta.l salts. Also, in the Cornell study, the soil column received a year's worth of rain in one month which would promote saturated conditions which could promote leaching. The conclusions to the Cornell Paper itself indicates that the study may not be applicable to biosolids. The conclusion states "While this study demonstrates that preferential flow paths in undisturbed soil make a considerable difference when considering solute transport through soil, it may not be directly applicable to sludge-applied metals. Metals applied in this experiment were soluble metal salts, whereas metals in sewage sludge would not necessarily react in a similar manner since the high organic content of sludges retains metals strongly (at least initially)" [USDA

believes that other factors beyond organic matter will limit metal mobility in the long term as well]. The National Research Council also states "...heavy metal cations would not be expected to leach out of the unsaturated zone into ground water." According to USDA, in field studies where drainage waters were collected, very little or no change in percolate metals have been observed.

Review of research on field sites - the Cornell Working Paper also indicates that a review of field study data shows that up to half the metals applied with the sludge appear to missing in the soil and may have leached. The fact that the metals are thought to be missing is because the soil samples in the same plot (the application area) do not indicate the level of metals applied. According to USDA, although some studies indicate finding only 50% of applied metals in the soil horizon after many years, when these soils are examined the evidence indicated that lateral movement of metals from the original plots occurred due to tillage and deeper incorporation than 15 cm due to moldboard plowing, not metal loss to leaching. Where careful evaluation was made, nearly 100% of metals applied are found on the plots.

b. Surface water impacts - for the Part 503 risk assessment the potential surface water impacts were determined by calculating or assuming erosion potential, biosolids application area, watershed area, buffer to surface water body, and other related factors. The biosolids application area (1074 hectares equaling 2653 acres) is based on the National Sewage Sludge Survey. This is the acreage used by the 90th percentile of the treatment plants (some of the largest plants). The watershed area is taken from the USGS as the mean size in the country. EPA also assumed that the buffer zone to the surface water body is 10 meters (32 feet).

Since the surface water pathway (pathway 12) was not controlling for any pollutant, a safety factor of at least 64 to 1 is included in the pollutant standards in Part 503. In New York State, there are numerous management practices that apply to the agricultural use of Class B biosolids (and Class A biosolids when necessary) that further minimize the potential fo~ runoff and surface water impacts including slope restrictions, soil type restrictions, incorporation requirements, minimum buffer to surface water of 200 feet, and restrictions an application on frozen ground and during rainfall. Currently, a total of approximately 4,000 acres of land are used for Class B in New York State, covering multiple watersheds. Currently in New York State, the acreage used is less than the EPA risk assessment values and many additional management practices are required.

Cornell Concern:

10. Not protective of agricultural productivity.

a. Phytotoxicity and crop yield reduction.
b. Soil microorganisms.
c. Animal health.

Brief Statement of Concern:

a. Sludges are applied to agricultural lands with a goal of increasing productivity through the addition of nutrients and organic matter. Excessive application of some contaminants, however, can reduce crop yields; risks vary among different soils and crops. Since these pollutants do not degrade, it is critical to limit their addition to protect the long-term productivity of the land.

b. There are concerns with soil microorganism impact from metals and Part 503 does not set limits based on soil organisms.

c. Animals that ingest soils on pastures are not sufficiently protected by the Part 503 standards.

Response :

a. Phytotoxicity and crop yield reduction - USDA and EPA argue that Cornell's concerns about phytotoxicity and crop yield reduction under the Part 503 rule are clearly without technical basis. According to USDA, the pollutant standard proposed by NYSDEC (derived from Part 503, Table 3) represent a no observed adverse effect level, meaning research with this quality biosolids has not shown any adverse effects on crop yield given normal management practices (pH adjustment for crop growth)are used.

The Cornell Working Paper indicates that the 1985 Pennsylvania State University report, often called the Northeast Criteria, recommends cumulative loading limits for copper, zinc, and nickel that are approximately one tenth the Part 503 limits. This is incorrect. The Northeast Criteria range from 1/6 of Part 503 limits to 1/54 of Part 503 depending on the various soil texture classes. The Northeast Criteria recommends a maximum copper addition of 25.0 lbs per acre in loamy sand and sandy loam. This equates to a soil concentration of about 12.5 ppm in the plow layer. According to the U.S. Geological Survey (USGS), analysis of agricultural soils yields an average copper concentration of 50 ppm with a range of 5-150 ppm. Therefore, if a given farm field has

an average copper concentration of 50 ppm and adds the maximum recommended by the Northeast Criteria for loamy sand (12.5 ppm), then the resulting soil concentration would be 62.5 ppm (50 + 12.5), which is below the upper range of copper concentration found in uncontaminated agricultural soil. This appears to imply that uncontaminated agricultural soil can cause phytotoxicity due to natural copper content. This is not the case.

The National Research Council has reviewed the issue of phytotoxicity from biosolids application and concluded "Therefore, as long as agricultural use of treated sludges and wastewater is in keeping with existing regulations and sound agronomic practices, the possibility that trace elements applied from this practice would adversely affect the yield or wholesomeness of crops is remote."

For the risk assessment, multiple procedures were used to establish phytotoxicity limits, and the procedure yielding the most stringent limit for a given metal was chosen as the pollutant limit for Pathway 8, the phytotoxicity pathway. These methods are described in greater detail below.

First Procedure for Determining Plant Metal Concentrations That Characterize Phytotoxicity (the Probability Approach)

STEP 1. EPA searched the literature to identify plant tissue concentrations of metals associated with amount of growth. In the experiments analyzed, different species of plants were grown in nutrient solution or pots of soil with and without additions of different test metals salts for two to six week periods. The studies determined the concentrations of different metals in the vegetative tissues of various plant species associated with 8, 10, 25, and 50% retardation of vegetative growth, measured as shoot growth. The leaf concentration associated with 50% growth reduction was selected as the phytotoxicity threshold (PT50) for use in the risk assessment for the phytotoxicity pathway. The PT50 was used because EPA determined that relatively severe initial effects (50 percent or greater growth reduction) would be necessary to correspond to later yield reduction, given that short-term growth effects do not necessarily translate into longer term yield reductions at maturity (the actual criterion used to define phytotoxicity). Exceeding the phytotoxicity threshold one out of every 100 times was considered acceptable. Even if the Agency has chosen a 25% reduction in growth (PT25) as the phytotoxicity threshold, the maximum loading rate (i.e., that

would not exceed the threshold leaf concentrations) would not have been meaningfully different from that calculated using the PT50' It is important to note that detection of significant growth reduction in the field (across seasons for any crop) of less than 25% from any cause is very difficult.

STEP 2. Next, EPA used data from biosolids field experiments in which corn or soy-beans had been grown. Because EPA had previously determined that uptake of metals by plants grown on biosolids amended soils in the field cannot be simulated by plants grown in pots, EPA limited uptake data strictly to that obtained from field studies. EPA calculated geometric means and standard deviations of metal concentrations in plant tissues corresponding to various soil metal loadings. These data were then used to determine probabilities of reaching the PT50 for each metal in each plant
species. Corn was selected as the focus of the analysis because more field data were available for corn than for any other plant species. A value of 0.01 was selected as an acceptable level of tolerable risk for exceeding the PT50* In actually, the risk was significantly less than 0.01 at all biosolids loading rates analyzed, the highest of which were 3,500 kg/ha for zinc and 1,500 kg/ha for copper.

Second Procedure for Determining Plant Metal Concentrations That Characterize Phytotoxicity (the Calculation Approach)

A problem inherent in the Probability Approach discussed above is that corn is not very sensitive to phytotoxicity from metals; thus, a second procedure also was used to characterize phytotoxicity. In EPA's second procedure, plant tissue concentrations associated with yield reduction were obtained from the literature to define an upper bound on phytotoxic effects for sensitive plant species (e.g., lettuce). Sensitive plant species are more susceptible than corn to metal-induced inhibition of growth (phytotoxicity). These data were used to develop plant tissue levels of metals of metals associated with first detectable yield reductions. These concentrations were identified as the phytotoxicity threshold for each of the four metals.

Selection of the Most Conservative Loading Rate From the First and Second Approaches as the Phytotoxicity Limit

For zinc, a mean of 2,800 kg/ha was calculated as the loading rate using the second procedure described above which was compared to the value determined using the Probability Approach (first procedure, described above). A limit was never actually reached for zinc using the

Probability Approach (i.e., no phytotoxicity was observed even at the highest loading rate, so the highest loading rate analyzed, 3,500 kg/ha, was identified as a "limit"). The 2,800 kg/ha, the more conservative rate, was chosen as an appropriate pollutant loading rate for zinc.

For copper, a mean of 2,500 kg/ha was calculated as the pollutant loading rate using the Calculation Approach, which was compared to the value identified in the Probability Approach (cumulative loading rates up to 1,500 kg/ha). The more conservative of these two values -- the 1,500 kg/ha -- was chosen as the appropriate limit for copper.

Similarly, for nickel, a limit of 2,400 kg/ha was calculated using the Calculation Approach as compared to 420 kg/ha for the Probability Approach. The more conservative value of the two, 420 kg/ha, was chosen as an appropriate limit for nickel.

Holistic Review of Field Data To Determine if Phytotoxicity Limits Were Protective

A comprehensive review was made of plant metal concentration data and yields from all available biosolids field studies, including all data reflecting various soil types and biosolids sources. This review found no instances of phytotoxicity concentration limits being exceeded nor yield reductions, even in crops that tend to accumulate metals and exhibit phytotoxicity symptoms, such as Swiss chard, lettuce, and soybeans, unless the biosolids contained very high concentrations of metals (above Part 503 ceiling concentrations) or the plants were grown in soils at very low pH.

The studies where phytotoxicity did occur were considered atypical because of abnormally high metal concentrations in the biosolids or very low soil pH. These high-metal biosolids can no longer be land applied due to pretreatment standards and/or because they are excluded from being land applied by the ceiling concentration limits in the Part 503 rule. In addition, the agricultural use of soils with low pHs (below 5.5) is unlikely because normal agronomic practice calls for maintaining soils above pH 6.0 to prevent the solubilization of naturally occurring metals in soil, such as aluminum and manganese. These metals can have a significant toxic effect on plants (whether or not biosolids are used). Hence, data from these atypical field studies were not used in developing the final phytotoxicity pollutant limits.

b. Soil microorganisms - according to EPA, most studies have shown no adverse effects on soil microbial activity associated with metals in
biosolids or soil (including nitrification and mineralization of

nitrogen, as well as normal development and functioning of nitrogen fixing bacteria for legumes, other than white clover). In one study, however, on land known as the Woburn experimental plots in England, a strain of *Rhizobium* lost its ability to fix nitrogen on one strain of white clover. This loss in ability was noted after a 19-year period of biosolids application to sandy soil on which vegetable crops were being grown.

Several studies have found effective strains of white clover *Rhizobium* in farm fields rich in metals. One such study involved soils near a zinc smelter in Pennsylvania, where zinc and cadmium levels in the soil were much higher than in the Woburn study.

Other research on mine spoils with high levels of metals, analogous to free metal salts in soil, has shown that nitrogen fixation was inhibited in free-living bacteria, but not by white clover *Rhizobium* until metals levels were so high that phytotoxicity to white clover plants was observed. For all the above reasons, EPA concluded that it was not appropriate to use data from the Woburn study to limit metal applications for the Part 503 rule.

A new study provides strong evidence that biosolids were not the cause of *Rhizobium* becoming ineffective on the Woburn plots. Instead researchers determined that low soil pH caused selection of ineffective strains of *Rhizobium* in both experimental controls (soils without biosolids added) and biosolids-amended soils.

c. Animal impacts for grazing - the Cornell Working Paper raises concerns about assumed animal soil ingestion rates, pathogens, and metal toxicity to grazing animals.

Fraction of animal diet that is sewage sludge - the fraction of sludge ingested (adhering to plants and/or directly from the soil surface) by grazing cattle has been estimated to be 2.5 percent averaged over a season. These data are derived from cattle feces studies, where livestock were not allowed to graze in pastures during sludge application or for a 21 day period after application. However, given that (based on discussions with regulatory officials in several states) the maximum fraction of a farm treated with sludge is approximately 33 percent in any one year, if it is assumed that the cattle are rotated among several pasture fields, the actual fraction of the diet that is sludge will be lower than the 2.5 percent assumed.

Cattle grazing on land treated with sludge compost that was applied during the previous growing season have been shown to ingest

approximately 1.0 percent sludge. When a weighted average is calculated from these two values of sludge ingestion (i.e, 0.67 x 1.0 + 0.33 x 2.5), the long-term average percent of sludge in diet is estimated to be 1.5.

Pathogen risk to grazing animals - Part 503 requires a waiting period of one month before grazing animals on soil where Class B biosolids have been applied. As mentioned by the Cornell Working Paper, the National Research Council has advised EPA to re-evaluate the adequacy of the 30-day waiting period. In New York State, Class B sludges must be incorporated into the soil which reduces the risk to grazing animals. Also, none of the Class B sludges current land applied in New York State are used on pasture land and the NYSDEC is willing to incorporate the NRC recommendation into State regulation. For Class A sludges, the pathogen content is below detectable levels and therefore, risk to grazing animals is minimal.

Metal toxicity to grazing animals - the Cornell Working Paper raises concerns about a number of pollutants and their impact on grazing animals, including selenium, molybdenum, iron, lead, and arsenic. For the Part 503 risk assessment the available literature was reviewed for each pollutant to estimate the maximum intake of a pollutant that would not cause a toxic effect to a most sensitive/most exposed herbivorous animal. Unlike the reference intake of pollutant in humans, which is expressed as an allowable daily intake of pollutant, the threshold pollutant intake (TPI) in this pathway is referenced in the literature as an allowable pollutant concentration in the animals' diet. TPI levels are taken directly from recommendations by the National Academy of Science, except in the cases of copper, molybdenum, selenium, and zinc. The TPI levels for copper, molybdenum, selenium, and zinc where derived from NAS recommendations and review of other animal studies in this area.

Also, a number of studies have been conducted on the effects of feeding sewage sludges to animals either directly or where animals have ingested sewage sludge that was sprayed on forage. Few adverse health effects have been found in these intense feeding studies.

In addition to the traditional pollutants, the Cornell Working Paper raises the issue of iron content. Toxic effects due to iron have only been observed under atypical conditions -- in experiments with unusually high concentrations of iron and fluoride and single high volume applications of biosolids.

For example, cattle in which iron toxicity results were grazed on land

to which, in an experiment, high iron content biosolids were land applied a day before grazing. These cattle received no supplemental feed and were continually rotated to new fields week after week immediately after the field had been treated with high iron-content liquid biosolids.

Such an occurrence of elevated iron toxicity in cattle is highly unlikely other than in a similar experimental setting. The Part 503 rule requires at lease a 30-day waiting period after application of Class B biosolids (those meeting certain pathogen reduction requirements) before allowing grazing. Possibly, Class A biosolids (virtually pathogen free) could be applied just before grazing, however, Class A biosolids are usually in a dry state and initially do not tend to stick to the forage, as do liquid Class B biosolids. Also, it is highly unlikely that biosolids in any form would continue to be applied week after week to pastures immediately before cattle graze. Also, as mentioned above, NYSDEC requires incorporation of Class B biosolids.

After publication of the Part 503 regulations, USDA published recommendations for selenium and molybdenum that would produce added safety for grazing animals. NYSDEC is proposing to incorporate the USDA recommended standards. Also, this pathway (pathway 7) was not controlling for any standards so additional safety for this pathway is built into the standards.

Cornell Concern:

11. Inadequate assessment of pathogen risks.

Brief Statement of Concern:

Class B sludges contain significant pathogen levels. Little is known about the leaching of pathogens to groundwater from sludge applications sites.

Response:

In Part 503 there are two levels of pathogen reduction -Class A and Class B. Class A is the highest level of treatment, resulting in an essentially pathogen free material (pathogens below the detection limit). For biosolids to be distributed to the public or used in a manner where public exposure is likely, Class A pathogen reduction is required.

Class B pathogen reduction, formerly know as a process to significantly reduce pathogens (PSRP), reduces the pathogen content of the biosolids by at least one log, but does not necessarily eliminate all pathogens. Class B biosolids do not pose a threat to public health and the environment as long as actions are taken to prevent exposure to the biosolids after application. Part 503 contains management practices that are required to be followed when Class B biosolids are applied to minimize exposure. The management practices include restrictions on the growth of food crops, animal grazing, turf growing, and public access. EPA believes, provided the management practices are followed, Class B biosolids use is as safe as Class A biosolids use.

The two tier system of pathogen reduction has been in place in federal regulation since 1979. According to the NRC, there have been no reported outbreaks of infectious disease associated with a population's exposure - either directly or through food consumption pathways - to adequately treated and properly distributed sludge applied to agricultural land. Also according to the NRC, cause bacteria and viruses in biosolids are strongly sorbed to the solids, they are not usually desorbed in the soil, and are not likely to be transported to groundwater. An Ohio biosolids study found no evidence that humans or animals where impacted negatively by biosolids application.

In addition to the Part 503 management practices applicable to Class B biosolids, in New York State each site where Class B biosolids are applied must be permitted under 6 NYCRR Part 360 and additional site restrictions apply (soil type, depth to groundwater and bedrock, slope, buffer zones to wells, residences, etc.). These additional criteria add further protection of public health and the environment.

Cornell Concern:

12. Ecological impacts inadequately addressed.

Brief statement of concern:

Ecological impacts are not sufficiently addressed in Part 503. Results of the Oak Ridge study should be reviewed to determine possible Part 503 revisions.

Response:

EPA evaluated ecological risks (potential adverse effects on plants and animals) in its risk assessment for land application of biosolids. The

risk assessment used the best available ecological data from the scientific literature. Where data were extensive (e.g., on the phytotoxicity of agricultural crops), a comprehensive risk assessment was possible. Where data were more limited, such as for small wildlife and non-agricultural plants in an unmanaged environment, a much more limited approach had to be used for estimating ecological risk. Another difficulty encountered was that currently there is no universally approved procedure for assessing ecological risks.

For animals, risks were evaluated for:

* Agricultural livestock ingesting crops grown on biosolids-amended soil.

* Small herbivores (e.g., deer mice) that live their entire lives in a biosolids-amended area feeding on seeds and small plants close to the biosolids/soil layer in fields, forests, and public contact sites (e.g., parks).

* Animals grazing on forages grown on biosolids-amended forest land or reclamation sites.

* Animals ingesting biosolids (i.e., soil) directly while grazing.

* Soil organisms (e.g., earthworms) living in and consuming biosolids-amended soil.

* Animals that eat soil organisms living in biosolids-amended soil (i.e., soil organism predators).

For plants, EPA used a comprehensive approach to establish pollutant limits that would protect plants from the potentially phytotoxic metals in biosolids (zinc, copper, nickel, and chromium). Multiple procedures were used to establish these limits, and the procedure yielding the most stringent limit for a given metal was chosen as the pollutant limit for pathway 8, the phytotoxicity pathway.

As noted earlier, ecological data are limited. Moreover, at the time the Part 503 risk assessments were conducted, EPA did not have an Agency-wide approved procedure for conducting comprehensive ecological risk assessment. As a result, the biosolids risk assessments did not examine effects on species populations or communities; however, EPA did use the best available data on toxicity to wildlife and plants from pollutants in biosolids in this ecological risk assessment. In so doing, EPA evaluated risks to the most sensitive or most exposed species

for which such toxicological data existed.

As is always the case with limited data sets, additional experimental data would be desirable. To improve its ability to consider ecological risk from land application of biosolids in the future, EPA has committed to conduct and support work by others on the ecological impacts of biosolids risk from land application of biosolids in the future, such as the Oak Ridge study. EPA also is working on the further development of a methodology that can gain widespread approval for use in conducting full ecological risk assessments.

Cornell Concern:

13. Inadequate enforcement and oversight.

Brief Statement of Concern:

Inadequate enforcement and oversight of regulations at federal and State level.

Response:

For the beneficial use of biosolids, Part 503 does not require site specific permits to be issued prior to operation. However, all sewage treatment plants larger than 1.0 MGD (million gallons per day) or that serve more than 10,000 people must apply for a federal permit. Also, any biosolids treatment facility located at a location other than a STP must apply for a federal permit, such as a regional composting facility. These facilities must report to EPA annually.

All biosolids beneficial use facilities are required to comply with the federal criteria and must maintain sufficient records to show compliance. EPA has conducted numerous inspections in New York State and has issued fienes for non-compliance.

In New York State, biosolids beneficial use facilities are subject to permitting and oversight under 6 NYCRR Part 360 Solid Waste Management Facilities. A site specific permit is required for all Class B application sites and a facility permit is required for all Class A (composting, etc.) facilities. A Part 360 permit is required prior to construction and operation. The permit application requires detailed information on the site, monitoring, application rates, etc. A licensed professional engineer is required to certify the information is accurate. The NYSDEC has staff in each of our nine regional offices and

the Central Office to oversee and enforce against the permitted beneficial use facilities currently in operation in the State. Also, in the proposed regulations under development, NYSDEC will require all biosolids destined for beneficial use in New York State to meet the most stringent federal standards in Part 503, providing a significant degree of safety beyond the federal rule. All State permitted facilities must provide detailed reports to the NYSDEC at least annually; larger facilities must report quarterly.

Cornell Concern

14. No labeling of sludges or sludge products.

Brief Statement of Concern:

In order to compare among sludges and sludge products, users need information on the product quality. Federal rules do not require suppliers to provide such information for sludges meeting "EQ" standards.

Response:

Under Part 503, biosolids products that meet Exceptional Quality (EQ) standards are considered safe for public distribution similar to all other fertilizers and soil amendments. Currently, there are no federal standards that require the labeling of any fertilizer or soil amendment for pollutant content. Any labeling requirement should be universally applied to all commercial products, not solely biosolids products. In New York State, existing and proposed regulations require biosolids products to provide a label or information sheet with quality data and other user information.

BRIEF RESPONSES TO "RECOMMENDATIONS REGARDING APPLICATION OF SEWAGE SLUDGES OR AGRICULTURAL LANDS OR GARDENS"

A copy of the Cornell Working Paper recommendations is found at the end of this section.

Responses:

RECOMMENDATIONS TO THOSE WHO ELECT TO USE SEWAGE SLUDGES OR SLUDGE PRODUCTS

Sludge and Soil Quality

1. According to EPA and USDA, based on the body of research available concerning biosolids, there is no scientific basis for requiring the standards in Table 10, other then for lead (which equals the Part 503 Table 3 limit). As outlined in the National Research Council report, animal manure can contain metal concentrations higher than the standards recommended by the Cornell Working Paper. Therefore, if the Cornell recommendations are to be followed, testing and possibly tracking of metal loading from manures should be required. In addition, other generally considered "clean" materials, such as yard waste compost can exceed the levels deemed to be safe by the Cornell Working Paper and, in their view, pose a phytotoxic concern.

2. As outlined under #1, EPA and USDA have stated that there is no scientific basis for the Table 10 standards. Also, there is no definition of "high rates" or "many applications" and this contradicts recommendation #1 which would allow application as long as the soil concentration does not exceed the level in Table 10, regardless of the number of applications involved. Again, as mentioned in response to #I, this standard could restrict the long term application of animal manures.

3. A nutrient management plan to address all nutrient inputs on a farm is desirable. Under Part 503, all non-EQ biosolids are required to be applied at or below the agronomic rate when used in agriculture. In addition, under State regulations in New York State, application rates must be justified and approved by the NYSDEC and nitrogen addition can not exceed crop needs. Therefore, application of biosolids on agricultural land where nutrients are not needed or in excess of the amount of nutrient needed is a violation of State regulations. Excess

application of any nutrient source (manure, commercial fertilizer, or biosolids) is recognized as a groundwater and surface water concern.

4. Obtaining information on nutrients being used is desirable and useful. Indemnification from a generator will depend on who is responsible for the series of activities. For example, a generator may be responsible for biosolids quality, but the farmer will apply the biosolids. In this case, the farmer indemnification may be limited to biosolids quality issues.

Testing

5. The pollutants that are regulated in the Part 503 rule were determined after evaluating in excess of 400 potential pollutants in biosolids. EPA feels that limiting the monitoring of pollutants to the list of nine metals regulated in Part 503 is appropriate as the minimum level of monitoring frequency established in the rule. The phrase "products with consistently low levels of contaminants" is meaningless unless numerical limits for pollutants in biosolids are defined. EPA firmly believes that the quality of biosolids is more than adequately defined by the numerical standards of Part 503.

In New York State, as part of a permit application, the NYSDEC is proposing to require extended analyses. This will give added assurance that there is not a pollutant of concern in the biosolids prior to application. Requiring the supplier to provide extended analyses to a farmer without guidance on acceptable levels is useless to the farmer.

Providing users relevant quality information on biosolids is a good idea. However, the recommendation states "Consumers including farmers should be able to compare among various products...". Requiring detailed information on biosolids will not provide this information to farmers because other products, such as commercial fertilizer, are not required to provide pollutant data on their products.

6. This recommendation for farmers is acceptable. Proper soil testing will help insure maximum crop yield from pH adjustment and proper nutrient loading, in addition to assessing metal loading. The risk of phytoxocity is so low that mandatory testing is not warranted.

7. The testing of wells is not necessary. The Part 503 risk assessment evaluated the potential metal movement to groundwater and is protective of this pathway. Metal movement to groundwater is under the federal rule is not a concern. In addition, in New York State there are setbacks, soil type restrictions, slope restrictions, separation to

groundwater, etc. that further minimize metal movement to wells. According to the National Research Council "...because bacteria and viruses in sludge are strongly sorbed to sludge solids, they are not usually desorbed in the soil, and are not likely to be transported to groundwater." Also, Dr. Gerba (a recognized expert in pathogen transmission and disease) has stated "We've been able to detect no potential for groundwater contamination resulting from land application of biosolids. In addition, as long as the new regulations [Part 503] and monitoring requirements are met, any risk to human health from land application is minimal." Again, additional requirements in New York State further minimize potential movement.

Uses and Management Practices

8. As discussed in greater detail in the response to concerns this caution is overstated and is addressed by requirements in Part 503 and New York State's Part 360.

9. Valid recommendation.

10. Soil pH should be maintained as recommended for proper crop yield. The risk assessment evaluated low pH situations and is protective of soils where any effort has been made to maintain pH in a desirable range for plant growth. In cases of low pH, plant retardation has been found to be caused by naturally occurring elements such as aluminum and manganese. Additional protection is found in New York State where the proposed regulations require all biosolids to meet the most stringent limits and (both current and proposed) State regulations require pH adjustment to 6.5 or greater for Class B biosolids land application.

11. The federal Part 503 regulations contain vector attraction reduction requirements which can also reduce odor concerns (liming, incorporation, etc.) and buffer zones and other requirements to prevent surface water impacts. New York State requires Class B sludges to be incorporated within 24 hours and requires buffers, soil type restrictions, etc. to minimize odor migration and surface water impacts.

12. Valid recommendation. State regulations require such buffer zones and all regulatory requirements must be followed.

13. As with any fertilizer or soil amendment, non-point source pollution is a concern and efforts must be made to minimize potential runoff. For non-EQ biosolids Part 503 requires a buffer to surface waters and prohibits allowing runoff into wetlands or water unless under a permit. New York State regulations go ever further and have soil type and slope

restrictions, increased buffers, application time restrictions (no application on saturated ground, etc.). No such restricting regulatory requirements apply to any other fertilizer material applied by a farmer.

14. Good hygiene is always a good recommendation. In many cases, a sewage treatment plant operator is the one most exposed individual to these materials.

15. Valid recommendation.

16. Valid recommendation.

17. For children which have an abnormal tendency to consume dirt, parents should take precautions to reduce their exposure to soil and soil products, such as biosolids, compost and manure.

18. Part 503 is protective of use of biosolids in the home garden and this recommendation is not needed to protect public health.

SUGGESTIONS FOR POLICIES AND REGULATIONS

General

1. NYSDEC has evaluated the Part 503 regulations and believe they are protective of public health and the environment. However, NYSDEC has proposed a number of additional criteria, more stringent then 503, that provide significant additional safeguards for the people and environment of New York State. These include:

-A continued comprehensive permitting program for all biosolids beneficial use in New York State.

-All biosolids beneficially used will be required to meet limits equal to or more stringent then Table 3 (the most stringent levels in Part 503).

-Higher testing frequency then Part 503.

-Testing for expanded parameters.

-Many more management practices (site slopes, etc.).

-More detailed recordkeeping and reporting.

2. Agreed. Any new research involving biosolids will be reviewed to determine potential impact on State regulatory criteria.

3. &
4. As stated earlier, NYSDEC believes the Part 503 methodology is valid and NYSDEC has built in additional safeguards. The NYSDEC does not believe the standards proposed by the Cornell Working Paper are necessary to protect public health and the environment. Imposition of these standards would also preclude the use of some manures, yard waste composts, and similar materials.

Under Part 503, each pathway was evaluated separately and the most stringent pathway for a particular pollutant was used for the standard. Therefore, additional safeguards are built into the standards. For example, if the child ingestion pathway set the standard for arsenic since it was the lowest allowable amount, surface waters are further protected since that pathway derived a higher allowable amount. Reverting to the individual pathway standard, as suggested by the Cornell Working Paper, would in some cases provide less protection.

6. &
7. The development of additional standards under Part 503 is under the auspices of EPA. NYSDEC will work with EPA in any manner that is productive in developing a protective standard.

Currently, biosolids products imported into New York State must meet the same State standards that apply to products generated in New York State. Information on quality, quantity, etc. must be submitted to the NYSDEC prior to use in the State and continued monitoring and reporting is required if the material is allowed to be brought into the State under this provision.

Monitoring and Labeling

9. NYSDEC currently requires labels or information sheets for biosolids products that indicate the type of waste involved, any restrictions on use, and recommended safe uses and application rates. The draft State regulations also require reporting of pollutant levels. Pollutant level information will only be useful for comparative purpose if it is required for all fertilizer products, which is currently not the case.

10. Although not required by federal Part 503, NYSDEC is proposing to require expanded analyses based on treatment plant size and industrial input.

11. NYSDEC is proposing to require testing for both fecal coliform and Salmonella sp. in Class A biosolids and will require non-detection of Salmonella sp.

12. NYSDEC does not believe groundwater monitoring is necessary given the numerous other criteria applicable to the land application of biosolids (pollutant standards, application rate restrictions, site restrictions, etc.).

13. NYSDEC currently requires the restriction of public access to Class B biosolids land application sites by the use of fences and gates or signs. Information on access restrictions is available to the farmer and incorporation requirements (within 24 hours) reduce potential risk to farm workers.

14. EPA has reviewed existing data and regulations applicable to radioactive materials and will develop appropriate monitoring and standards if necessary. In addition, the Nuclear Regulatory Commission is developing guidance on radioactive materials for sewage treatment plants.

Home Use

15. Agreed. NYSDEC believes that the APLR approach is inappropriate and this approach is not proposed for the State regulations.

16. Based on the federal rule and risk assessment, the State does not believe this is necessary to protect human health and the environment.

Compliance and Permitting

17. Under current State regulations, Class B sludges must be incorporated into the soil within 24 hours. A facility may apply for a variance to this requirement, but one of the requirements of a variance is that the applicant must demonstrate that the proposed activity will have no significant adverse impact on the public health, safety or welfare, the environment or natural resources.

18. Ensuring compliance with regulatory standards is a primary NYSDEC function. The NYSDEC maintains staff in nine Regional Offices and a Central Office to complete this task.

Research and Pollution Prevention

19., 20.& 21. Continued and expanded research and pollution prevention are desirable.

Given the limited amount of research funds available, research dollars should be focused on topics where limited data is currently available. Given current budgetary constraints felt by local governments, and the limited risk involved, any new fee must be clearly necessary.

RECOMMENDATIONS FOR HOME GARDENERS WHO HAVE ALREADY APPLIED SLUDGE PRODUCTS

1-7. The recommendations concerning the use of sludge products in the home garden are without scientific basis and will produce undue concern in the general public. The Part 503 risk assessment developed standards to protect child exposure and garden food consumption where biosolids products have been used. This is supported by the EPA, USDA, FDA, and the National Research Council of the National Academy of Sciences.

Recommendations Regarding Application of Sewage Sludges on Agricultural Lands or Gardens

Recommendations to those who elect to use sewage sludges or sludge products.

Sludge and soil quality

1. Limit application of sludges so that the soil concentrations in Table 10 (last column) are not exceeded. The numbers are for recommended maximum soil concentrations and will therefore depend on initial soil concentrations, the concentration of the contaminant in the sludge, the total loading of sludge applied and any losses (e.g. through leaching). Limiting application to these quantities will also help prevent excessive contamination with currently unregulated contaminants by limiting the amount of sludge that could be applied over time. Sludges with contaminant concentrations not exceeding the levels in ppm listed for maximum soil concentrations in Table 10 could be applied in unlimited cumulative quantity without exceeding the recommended soil concentrations for contaminants. (Application at appropriate annual rates to ensure that nutrient levels are not exceeded is still required.) For sludges exceeding the Table 10 recommended maximum concentrations, calculations should be made to determine the cumulative amount of sludge which could be applied without exceeding the recommended soil concentration.[1]

2. As a general precaution, do not land-apply at high rates or for many applications any sludge with contaminant concentrations greater than those listed as recommended maximum soil concentrations in Table 10.

3. Excessive application of nutrients resulting in leaching of nitrogen and excess enrichment of phosphorus in soils may result from sludge application, particularly on livestock farms where there may already be excess nutrients. Therefore apply only according to a nutrient management plan.

4. Obtain information from supplier (and applicator if sludge is spread by another party) which states that the sludge meets all required standards and that required application practices have been followed. Indemnification can also include a commitment to provide legal defense on behalf of the farmer should a lawsuit be brought.

Testing

5. Require the supplier to provide information on content of contaminants. Consumers including farmers should be able to compare among various products to select the one with the lowest contaminant levels and optimal nutrient content. In addition to the regulated contaminants, request information about synthetic organic chemicals (including dioxins and furans), antimony, beryllium, boron, chromium, silver, and

1 To determine the total number of tons/acre which could be applied for a sludge with measured contaminant levels apply the following equation: Total cumulative application in tons/acre=1000 x (max. soil concentration in ppm minus background soils concentration in ppm) divided by sludge contaminant concentration in ppm. For example: If a sludge contains Cd at 10 ppm, background soil is 0.2 ppm, and the recommended maximum soil concentration of 2 ppm is used, a total of 180 tons/acre could be applied {1000x(2 ppm - 0.2 ppm)/10 ppm] without exceeding we recommended maximum soil concentration, assuming all of the cadmium applied remained in the soil.

Contaminant	Typical Sludge Conc.'	Typical NYS Ag Soil	Recommended Soil Maximum Concentration
Arsenic	3-10	<9	1-10[2]
Cadmium	2-15	0.2	2[3]
Chromium	50-500	52	[4]
Copper	300-1500	20	40-100[5]
Lead	100-300	'15	3006
Mercury	1._10	0.1	1[7]
Molybdenum	5-50	1.0	48
Nickel	10-150	16	25-50
Selenium	2-6	0.4	510
Thallium	1-10	0.2	1[11]
Zinc	500-2500	60	75-200
PCBs	<5		1[13]

Values are in ppm.

Table 10. Recommended Maximum Concentrations of Contamination in Soils

1 Based on a survey of NYS sludges (NYS DEC, 1994) except for thallium, which is based on US sludge survey data.
2 Risk assessment based on child ingestion and 0.0003 RfD suggests 1 pprn concentration limit for sludges used at home (Texas Natural Resources Commission, 1996). Background soil often exceeds 1 ppm so a range suggested is potentially acceptable.
3 A limit of 2 ppm is recommended due to crop uptake concerns.
4 The chemical form of chromium is of critical importance. Cr III is of little concern because it forms relatively insoluble compounds, while Cr VI is highly toxic and soluble. Little information is available on die ionic status of Cr in sludged soils and the potential for chromium oxidation in sludged soils.
5 Concentration limit to prevent phytotoxicity based on the northeast guidelines (Pennsylvania State, 1985). 40 ppm for sandy soils, 60 ppm for fine sandy loam to silt loam, 100 ppm for silt to clay soils.
6 The lowest attainable levels are desirable since negative human impacts continue to be discovered at increasingly low levels. Child ingestion is the primary concern.
7 The lowest attainable levels are desirable- Ecotoxicologic and groundwatcr impacts are likely to be die determining factor.
8 Excessive molybdenum can result in molybdenum toxicity (induced copper deficiency) in ruminants. Testing forages for molybdenurn and copper periodical]), and preventing ruminants from grazing on land to which sludge has been applied and not incorporated into tile soil is recommended.
9 Concentration limit to prevent phytotoxicity based on the northeast guidelines (Pennsylvania State, 1985). 25 ppm for sandy soils, 35 ppm for fine sandy loam to silt loam-50 ppm for silt to clay soils.
10 This may be high. Test forages periodically for selenium to assure that concentration does not exceed that considered toxic to animals.
11 There arc no standards set by US EPA or NYS DEC and testing is not done routinely. Germany and Switzerland have a soil guideline of 1 ppm. Crop uptake and groundwater leaching are of concern.
12 Concentration limit to prevent phytotoxicity based oil the northeast guidelines (Pennsylvania State, 1985). 75 ppm for sandy soils, 130 ppm for fine sandy loam to silt loam, 200 ppm for silt to clay soils. Higher concentrations can be tolerated in calcareous soils.
13 Based on EPA recommended soil levels (US EPA, 1990).

thallium. If animals will be grazing or if growing forage, also request analyses for fluoride, iron, molybdenum and selenium and consider dietary metal ratios. Ideally the tests would pertain to the specific load of sludge or product being used (not a report from several years ago). When this is not possible, reports from several different sampling times should be compared to ensure that levels are relatively constant. Select only products with consistently low levels of contaminants.

6. Test soils before application to determine pH, nutrient requirements and metals concentrations. Avoid over-application of metals by testing for background levels before application and at least every five years in a sustained application program.
7. Test shallow water supply wells that are near and downgradient of field where sludges have been applied for metals and pathogens.

Note: In NYS, soil analyses for some constituents may be obtained through Cornell Cooperative Extension. Contact the Dept. of Health or DEC for information on other laboratories certified to perform analyses.

Uses and Management Practices

8. Caution is advised regarding application of sewage on land used for forage production or grazing. Toxicities can result from imbalances in trace elements, particularly molybdenum, selenium and copper. For Class B sludges, pathogens are a concern. If sludge or sludge products are used, do not apply to standing forage. If used, incorporation into soils is particularly important and analysis of the ratio of various metals in the animal diet is recommended.
9. Apply as you would manure, using a calibrated spreader to ensure accurate, uniform distribution. Prevent over application and avoid hotspots. If someone else is applying, make sure they spread properly. Visit fields where they have previously applied.
10. Maintain soil pH at 6.5-7.0 to minimize plant uptake and leaching unless contaminant levels are low, similar to backgTound soil concentrations or recommended soil values in Table 10.
11. Incorporation is recommended to prevent odor problems, enrichment of surface water runoff and deposition of dust or spray on crops. Spread sludges within one or two days of delivery and incorporate within 48 hours after application. Assume odors will always be a concern for neighbors when using sludges.
12. Maintain setbacks from streams, ponds, wells and property lines.
13. Avoid application on steep slopes, on saturated soils where runoff is excessive, or on shallow or extremely welldrained (coarse) soils where percolation to groundwater may be rapid.
14. Avoid contact with and inhalation of Class B sludges to reduce pathogen hazards.
15. Take delivery only after analytical reports have been examined, application plans have been understood and agreed to, and best management practices established
16. Check with NYS DEC, farm credit organization and person buying crops to determine any restrictions.

17. Avoid access to sludge products by children. (Home garden use presents the greatest potential for child exposure.)
18. Avoid use on home vegetable gardens (currently NYS regulations specify suth a restriction and require distributors to include such a restriction on the label or distribution information). Concerns about cadmium, thallium and synthetic organics are the primary reason for the recommendation. If a resident decides to use a sludge product, use one with low contaminant levels (preferably meeting the concentrations in the last column of Table 10).

Suggestions for policies and regulations

The following suggestions are based on a review of the US EPA Part 503 regulations in light of current research. NYS DEC regulations presently address some of these issues. The authors and other Cornell faculty and staff would be pleased to discuss these recommendations and assist in developing them into policies which can be implemented.

General

1. Reevaluate sludge land application. policy and regulation in light of the inadequacies in the Part 503 risk assessment.

2. Reevaluate and revise regulations to reflect the results of the US EPA supported study being conducted at Oak Ridge National Laboratories regarding ecological impacts of sludge application when these are available.

3. Consider adoption of maximum soil concentrations for contaminants (see Table 10 for recommended limits).

4. Consider the adoption of standards for "clean sludge" that are at least as restrictive as the values in the last column of Table 10. Any sludge product for which tracking of cumulative additions is not required should meet these values. For tracked products, include a ceiling limit (for NYS, the 95th percentile values for NYS sludges would seem a reasonable ceiling) and require a calculation of and limit application to the number of tons which could be applied before reaching the recommended maximum. soil concentrations in Table 10.

5. Consider regulating home use, agricultural use and othcr applications such as to golf course turf and roadside vegetation differently since exposure pathways and significance of impacts are very different. For home use, more stringent standards are appropriate, reflecting the greater likelihood of child ingestion of sludge and the potential for less careful management. For use on ag-ricultural lands, phytotoxicity concerns are of greater significance. For many other uses, these pathways are of less import which might result in less stringnt standards.

6. Work to develop standards for PCBs, dioxins and other organics such as detergent constituents.

7. Work to develop standards for other elements (such as thallium) reviewed in Round 2 by US EPA.

8. Consider measures to apply equal controls to sludge products imported from out of state.

Monitoring and Labeling

9. Consider implementation of labeling requirements for sludges and sludge products that include information on the source of the materials, the content of contaminants concentration, required and recommended management practices.

10. Require testing for synthetic organics and additional metals. Testing for priority pollutants and for dioxins and furans might be required when a permit for beneficial use of sludge is requested and periodically thereafter, with frequency depending on the size of the plant and whether or not it accepts industrial waste waters. In addition to the regulated metals, particular attention should be paid to antimony, beryllium, chromium, silver, thallium, and, if animals will be grazing or forage grown, also fluoride, iron, molybdenum and selenium.

11. Consider expanding pathogen testing to include both fecal coliform and salmonella and require non-detection of salmonella for Class A sludge.

12. Consider development of groundwater nionitoring requirements, taking spacial, temporal and analytic issues into account.

13. Consider requiring posting of sites where sludges have been applied and require information for farmworkers on the potential hazards of exposure and how they can be minimized.

14. Review existing data on use and disposal of radionuclides and assess potential exposures and require monitoring of sludges for radioactivity.

Home Use

15. Eliminate the Alternative Pollutant Loading Rate approach. Research shows that it is unreasonable to expect all home users to abide by restrictions printed on a label. It also potentially exposes children to materials which, if ingested, might represent an unacceptable risk.
16. Consider requiring any product available for home use to meet maximum concentrations listed in the last column ofTable 10 (in addition to pathogen control and labeling requirements).

Compliance and Permitting

17. Consider stringent criteria for allowing, surface application of Class B sludges based on strict necessity and an assessment of ecological and animal health impacts.
18. Support a strong compliance program including monitoring of sites, evaluation of compliance with management requirements and investigation of complaints.

Research and Pollution Prevention

19. Support research on nitrogen release rates, the movement of metals and pathogens to ground and surface water, the presence and impact of synthetic organic contaminants and of contaminants eliminated from Round 2 consideration due to inadequate data, and ecological impacts (including soil organisms). Some of this research needs to be northeast-based where soil conditions are more conducive to contaminant mig-ration to groundwater and soil and crop types render crops more susceptible to phytotoxicity.

Other topics can be investigated more generally.

20. Support pollution prevention through research, education, outreach, and technical assistance to promote continued improvement in sludge quality. NYS should establish pollution prevention vs. end-of-pipe pretreatment programs for businesses, local municipalities and trade organizations which might be linked to existing pretreatment.

21. Consider a fee on sludge generation as a partial funding source for necessary research, compliance programs and pollution prevention assistance.

Recommendations for home gardeners who have already applied sludge products

1. If possible, obtain test results from the supplier for the sludge product used and compare these with the recommendations in Table 10. If such data cannot be obtained, consider paying for an analysis. Your local cooperative extension may be able to advise you about obtaining a sample and getting an analysis for some of the contaminants. For other contaminants, the local or state health department may be able to provide a list of laboratories.

2. If a lot of sludge has been applied (for example if sludge or sludge products comprise 25% or more of the top six inches of the garden soil), spread out to dilute or remove. Mix what remains thoroughly and deeply into soil. Dilute it with topsoil or relatively clean organic matter such as leaf compost.

3. If sludge products have been used in vegetable gardens, consider converting these to ornamental gardens, lawn or ground cover. Establish a new vegetable garden on nonsludge amended soils. (Note that in NYS current regulations prohibit use of sludge or sludge products on crops for direct human consumption such as home vegetable gardens. Enforcement of this provision is through required labeling of products available to home users.)

4. Test soil for cadmium and lead. If higher than 2 ppm cadmium, either further dilute with clean soil or avoid growing leafy vegetables. Where lead exceeds 300 ppm in the soil (or 150 if you want to be very cautious), prevent access by small children who might ingest it.

5. In general, it is recommended to prevent access to sludged areas by small children who might ingest sludged soils to avoid potential exposure to pathogens (possibly an issue with composted sludges) and other contaminants.

6. In ornamental gardens, incorporate sludge products into the soil or if not possible, cover the soil where sludge has been applied with a thick layer of appropriate mulch to reduce the chances of a child ingesting die sludge and replace the mulch as needed.

7. If used where vegetables are grown, keep pH adjusted to approximately 6.5-7 to reduce uptake of lead and cadmium by plants.

LETTERS IN RESPONSE TO THE CORNELL WORKING PAPER FROM USEPA AND USDA

In April of 1997 NYSDEC provided a copy of a draft of the Cornell Working Paper to USEPA for review and comment. In response to this request, USEPA provided two letters in response and also asked USDA to review the document. EPA also responded directly to the.,Cornell Waste Management Institute. A copy of the correspondence follows.

REFERENCES

Camobreco, J. J., B. K. Richards, T. S. Steenhuis, J. H. Peverly, and M.B. McBride. 1996. Movement of heavy metals through undistribued and homogenized soil columns. Soil Science 161:740-750.

Chaney, R. L. 1995. Summary of 1) differences between USDA's views and those of USEPA under 40 CFR 503; 2) differences in the views of M. B. McBride and R. L. Chaney regarding the fate of potential effects of heavy metals in biosolids beneficially used on cropland; and 3) needed research to support long-term biosolids utilization on cropland. Letter from Chaney to A. R. Rubin, J. M. Walker, M. B. McBride and others.

Cornell Waste Management Institute. 1997. The Case for Caution - Recommendations for Land Application of Sewage Sludges and An Appraisal of the USEPA's Part 503 Sludge Rules.

Dorn, D. R., D. S. Reddy, D. N. Lamphere, J. V. Gaeuman, and R. Lanese. 1985. Municipal Sewage Sludge Application on Ohio Farms: Health Effects. Academic Press, Inc.

National Research Council. 1996. Use of Reclaimed Water and Sludge in Food Crop Production. National Academy Press.

New York State Department of Environmental Conservation. 1996. 6 NYCRR Part 360 Solid Waste Management Facilities.

Pennsylvania State University. 1985. NEC-28. Criteria and Recommendations of Land Application of Sewage Sludges in the Northeast. Bulletin 851.

Ryan, J. A. and R.L. Chaney. 1995. Issues of Risk Assessment and its utility in Development of Soil Standards: The 503 Methodology an example. Proceedings of the third International Symposium on Biogeochemistry of Trace Elements.

Straub, T. M., I. L. Pepper, and C. P. Gerba. 1993. Hazards from Pathogenic Microoganisms in Land-Disposed Sewage Sludge. Springer-Verlag New York, Inc.

USDA. 1997. Letter to USEPA containing review of Cornell Working Paper.

USEPA. 1992. Control of Pathogens and Vector Attraction in Sewage Sludge. Office of Research and Development. EPA/675/R-92/013.

USEPA. 1992. Technical Support Document for Land Application of Sewage Sludge. Document Nos. EPA-822/R-93-001a&b.

USEPA. 1993. The Standards for the Use or Disposal of Sewage Sludge. Title 40 of the Code of Federal Regulations, Part 503.

USEPA. 1994. A Plain English Guide to the EPA Part 503 Biosolids Rule. Office of Wastewater Management. EPA/832/R-93/003.

USEPA. 1995. A Guide to the Biosolids Risk Assessments for the EPA Part 503 Rule. Office of Wastewater Management. US EPA/8332/B-93-005.

Vermont Department of Environmental Conservation. 1997. Vermont WWTF Biosolids Sampling Project. Final Report.

Water Environment Foundation. 1997. Biosolids Recycling Facts.

SCIENTIFIC PEER REVIEW OF "THE CASE FOR CAUTION"

Paul C. Chrostowski, Ph.D., QEP
Sarah Foster
Damian Preziosi
CPF Associates, Inc.
Takoma Park, MD

Presented at the New York Water Environment Association
74th Annual Meeting
New York City, New York

February 3-6, 2002

CPF ASSOCIATES, INC.
7708 Takoma Avenue • Takoma Park, MD 20912 • T: (301) 585-8062 • F: (301) 585-2117 •
www.cpfassociates.com

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The Cornell Waste Management Institute (CWMI) has privately published a working document called "The Case for Caution". This document is highly critical of the Environmental Protection Agency's (EPA's) 503 Rule for the management of biosolids under the Clean Water Act. Its stated purpose is to make the technical literature on biosolids more accessible to the public. CPF Associates, Inc. conducted an independent peer review of the document. Our peer review clearly shows that "The Case for Caution" is a polemic advocating alternative views of biosolids rather than a scientific document.

We found significant deficiencies in two areas. First, CWMI has not adhered to generally accepted standards for publication of scientific research. Deficiencies in this area include the following:

- No independent peer review of the document,
- Failure to follow the scientific method,
- Failure to provide backup calculations or data,
- Failure to divulge the source of funding,
- Confusion about the concepts of risk assessment and risk management,
- Failure to acknowledge EPA's analyses of issues presented in the CWMI document,
- Biased use of the scientific literature,
- Conclusions that are not supported by or have no relation to analyses presented in the text, and
- Scientific citations presented out of context.

Second, most of the scientific conclusions drawn by CWMI are erroneous and/or misleading. The most significant deficiencies in this regard include:

- Violation of the basic scientific principle of conservation of mass,
- Lack of understanding of the fundamentals of risk assessment,
- Use of erroneous or misleading regulatory criteria and standards, and
- Inappropriately comparing concentrations in various environmental media.

New scientific evidence is constantly emerging with respect to biosolids and its chemical constituents. It is reasonable to anticipate that scientists, advocacy groups, and regulatory agencies will continue to evaluate new information as it becomes available. Following our examination of the Cornell document, however, we find that there is no evidence that EPA's risk assessment for the 503 Rule did not adhere to generally recognized principles of risk assessment and did not use all the scientific information available at the time. In addition, our review suggests that the conclusions drawn by EPA from the 503 Rule risk assessment were appropriate and health-protective given the context of the Clean Water Act and the state of risk assessment practice at the time the 503 Rule was promulgated.

1. INTRODUCTION

In August 1997, Ellen Harrison, Murray McBride, and David Bouldin of Cornell University's Waste Management Institute privately published a report entitled "The Case for Caution" ("Cornell document"). In testimony before the House Committee on Science[1], Ellen Harrison stated that the purpose of "The Case for Caution" was to make the technical literature more accessible to non-scientists. This report was highly critical of the U.S. Environmental Protection Agency's management of municipal sewage sludges under the Clean Water Act ("503 Rule").

In November 1997, the New York Department of Environmental Conservation (NYDEC 1997) published a technical review of the Cornell document. In addition to a technical assessment by NYDEC's in-house staff, this review included a response to the Cornell document by the EPA and the United States Department of Agriculture (USDA). The NYDEC concluded that there was no scientific basis for the criticisms and recommendations contained in the Cornell document and rebutted each point in the document based on scientific information or regulatory policy of the NYDEC. These conclusions were supported by appended information from EPA and USDA.

The Cornell document was revised in February 1999, but the revision did not respond to the issues raised in the NYDEC review. The information contained in the document was subsequently presented to the U.S. National Research Council Biosolids Committee in March 2001 without any substantive change from the February 1999 document. Neither the Cornell document nor the presentation, the results of which were presented in a public forum, had ever undergone an independent scientific peer review.

Synagro Technologies, Inc. requested CPF Associates, Inc., a Washington D.C.-area based scientific research and consulting firm with extensive experience in the human health and environmental impacts of waste management, to conduct an independent scientific peer review of the Cornell document. Our peer review finds that the Cornell document may be classified as an advocacy report or polemic rather than a scientific report. The recommendations in the Cornell document are largely unsupported either by information presented in the document itself or available elsewhere in the scientific or regulatory literature. The methods used by the authors of the Cornell document were biased and relied selectively on the scientific literature. Of the 12 major scientific issues raised in the report, all are refutable based on information contained in the scientific literature[2].

---

[1] Testimony of Ellen Z. Harrison, Director of the Cornell Waste Management Institute, before the U.S. House Committee on Science, March 22, 2000.

[2] The Cornell document also raised two issues that are not scientific and have no bearing on the 503 Rule – inadequate enforcement and oversight, and lack of labeling of sludges or sludge

This report presents the results of our peer review. It is presented in three sections. The first section presents overall comments on the scientific and technical quality of the Cornell document. The second section presents the 12 specific scientific issues raised in the Cornell document and general issues raised in the beginning of the Cornell document along with a brief critique and summary of information that refutes the Cornell document's hypotheses. The third section is a detailed scientific analysis of the general issues and each of the 12 specific issues complete with supporting calculations, data, and references to the scientific literature.

This peer review should be viewed as only preliminary as of this point. Although we have been able to evaluate many of the problems in the Cornell document, a complete assessment is beyond the scope of this peer review. In general, there are too many problems with the Cornell document to be discussed in a single peer review. We have attempted to supplement, rather than duplicate, the concerns raised in the NYDEC (1997) review. The reader is encouraged to consult the NYDEC review for additional perspective on the Cornell document.

2. GENERAL COMMENTS

As noted above, the Cornell document has not been independently peer reviewed. Peer review is an integral component of the scientific process. Normally this is accomplished by submitting an article to a scientific journal that offers peer review, constituting an independent board that conducts a peer review, or presenting information at a scientific meeting where there is opportunity for recorded discussion and debate about scientific issues. None of these options was followed for the Cornell document. This is in contrast to the 503 Rule risk assessment itself, which underwent extensive independent peer review. For example, the 503 Rule risk assessment underwent independent peer review by the Science Advisory Board and the USDA, and received a substantial amount of public comment. In addition, during the performance of the 503 Rule risk assessment, EPA relied on a team of outside experts including representatives from other governmental agencies, academia, the private sector and non-governmental organizations. Ironically, Dr. Robert Wagenett, department chair at Cornell's College of Agricultural and Life Science, was one of the outside contributors to the 503 Rule risk assessment (EPA 1995a).

The Cornell document authors did not follow the scientific method in development of their report. The scientific method is a value-neutral process that is subscribed to generally by scientists. In the scientific method, an investigator develops a hypothesis based on existing knowledge and/or research. Next the investigator attempts to refute or substantiate the hypothesis by means of a

---

products. This peer review focuses on only those issues that are relevant to the 503 Rule and are science or science-policy based. Thus, these additional issues, which are basically a matter of opinion, will not be considered here.

research plan. The results of this research are typically published in a peer-reviewed scientific journal or presented at a scientific meeting where they may be openly discussed. If the results of the research survive this process, independent investigators attempt to replicate the results. Once the results have been replicated and published a sufficient number of times, they are accepted as scientific fact. In contrast to this process, the Cornell document authors started with the value-laden premise that the 503 Rule was not health protective. Rather than positing rebuttable hypotheses, CWMI developed advocacy positions to support their initial premise and drew selectively from the scientific literature to support these positions. As noted above, CWMI's results were not peer reviewed, nor were they replicated. In fact, as we will show, the results are clearly not capable of replication due to the significant errors and bias in the document.

The authors did not present any supporting data or calculations. For example, on page 17, the authors refer to calculations for allowable levels of cadmium, yet they do not show any of their calculations or input data. This is in contrast to the 503 Rule risk assessment where all of the calculations and supporting data are available for scrutiny. One of the most egregious instances of this is the Cornell document's discussion of Monte Carlo simulation (page 7). In this discussion, CWMI basically criticizes EPA for failure to use a Monte Carlo approach with the implication that the Monte Carlo approach would be more health protective than the deterministic method used by EPA. CWMI does not present any data or calculations to show that this is actually the case. Without performing the entire Monte Carlo analysis, there is no way *a priori* of determining if it would be more protective, less protective, or exactly the same as the approach used by EPA.

The authors did not divulge their source of funding either for the Cornell document itself or for their underlying research. In science, it is considered ethical to divulge one's source of funding for research.

The Cornell document mixes the concepts of risk assessment and risk management. This distinction has been clear and significant since it was first elucidated by the National Academy of Sciences in 1983 (NAS 1983). This distinction is a theme that runs through all objective use of risk analysis by the federal government, the private sector, and the academic community. Since 1983, the significance of this distinction has been reaffirmed by the NAS (1994) and the Presidential/Congressional Commission on Risk Assessment (1996). Risk assessment is a formal scientific process that endeavors to give the most accurate representation of the probabilities and consequences of exposure to a chemical, biological, or physical agent in the environment. As such, risk assessment should be objective, value-neutral and free from bias. Risk management, on the other hand, uses the results of a risk assessment in conjunction with other information, including economics, sociology, engineering feasibility, public policy, and other relevant factors. The Cornell document has muddied the waters by purposefully blurring the distinction between risk

assessment and risk management. The danger inherent in this approach is that it attempts to cloak risk management opinions in the guise of risk assessment science. For example, the target risk selected for development of numerical standards for chemicals in the environment is a risk management decision without any basis in science. Yet, the Cornell document attempts to portray this as a scientific issue. Other examples where CWMI has confused risk assessment and risk management include:

- Reference to the "precautionary principal" which is a European regulatory policy concept,
- Criticism of enforcement of the 503 Rule which is a legal determination that cannot be made by scientists,
- Recommendation to support pollution prevention rather than health-based standards, and
- Recommendation to apply fees to biosolids generation.

The Cornell document fails to acknowledge that EPA and NYDEC have already analyzed many of the "issues" raised by the Cornell authors. For example, synergism, target risk levels, iron toxicity, phytotoxicity, and pH all were explicitly analyzed in the 503 Rule risk assessment (EPA 1995a). At the very least, the Cornell document should have acknowledged EPA's position on these issues and evaluated the weight of the scientific evidence to determine if it supported or refuted EPA's position.

The recommendations given on pages 31-35 of the Cornell document are not supported by discussion in the text and, indeed, in many cases have little or nothing to do with the remainder of the report.

The authors have attempted to cloak this document in the guise of science by presenting a reference list. There are many problems with this reference list. For example, only about one-third of the references cited were from peer-reviewed publications not authored by someone affiliated with Cornell. Many of the documents cited were personal communications, presentations at conferences and unpublished documents. It is not possible to evaluate the significance of scientific information contained in these materials or their relevance to the arguments raised by the Cornell document. Many of the documents cited are "self citations" – documents written by people affiliated with CWMI or other groups. Self-citation is akin to saying that "you should believe me because I said the same thing elsewhere." The credibility of a document is enhanced by citations of independent researchers.

The Cornell document also contains citations to many documents not included in the reference section. For example, documents cited as "Chaney 1995", "McGrath et al. 1994", and "Chou 1991" are all cited in the text but cannot be found in the reference section. This gives the impression that there is external

support from these other investigators to the claims made by CWMI, when actually the documents do not appear to exist.

There is a great deal of quoting out of context by the Cornell document authors. This is done by extracting a small citation from a document that may have negative implications for biosolids although the remainder of the document has positive implications. There are too many instances of this type of bias to deal with in this limited peer review; however, one example will illustrate this tactic. On page 18 of the Cornell document, the authors cite Chaney and Ryan (1994) as being "concerned that the uptake coefficients used in the US EPA risk assessment are too low", with the implication that the Chaney and Ryan (1994) report was critical of EPA's 503 Rule risk assessment for lack of protectiveness. In reality, the Chaney and Ryan (1994) report comes to the opposite conclusion. Chaney and Ryan (1994) developed an alternative process known as the "Clean Biosolids" approach for regulating metals in biosolids. Application of this method results in the calculation of No Observed Adverse Effect Levels (NOAELs) for biosolids that are extremely close to EPA's Exceptional Quality (EQ) limits for biosolids as may be seen in Table 1.

Table 1
Comparison of EPA 503 Rule to Chaney & Ryan (1994)

Metal	EPA EQ for Biosolids (mg/kg)	Chaney & Ryan NOAEL (mg/kg)
Arsenic	41	54
Cadmium	39	21
Lead	300	300
Mercury	17	17
Selenium	100	28
Copper	1500	1500
Nickel	420	290
Zinc	2800	2800

This table shows that Chaney and Ryan's values are identical to EPA's for 4 of the 8 metals regulated under the 503 Rule. In one case, Chaney and Ryan's value is higher and in three cases, Chaney and Ryan's values are lower, but within a factor of 3. The overwhelming majority of currently generated Class B biosolids is capable of meeting either EPA's or Chaney and Ryan's requirements and thus would be judged to be safe by the application of either set of criteria. Rather than presenting one minor quotation from Chaney and Ryan's (1994) article, an objective analysis would have referred to the entire Chaney and Ryan report including those portions that validate EPA's 503 Rule risk assessment conclusions.

Finally, the literature cited by the authors represents only a tiny fraction of the literature available on the issues raised in the Cornell document. For example,

regarding the issue of soil ingestion rates (Issue No. 5), the Cornell document authors cite one scientific study, one state regulatory document, and one unpublished Dutch report. There are literally hundreds of scientific publications written on this subject, most of which contradict the views of the Cornell document.[3] Further, the authors of the Cornell document ignored many of the most significant publications regarding potential health effects associated with biosolids. Examples of well-known documents that present alternate conclusions to those in the Cornell document include:

- The series of Biosolids Success Stories presented by the Water Environment Federation,
- Sterrett et al. (1996) who found that adding biosolids reduced the amount of lead taken up into lettuce from contaminated soil,
- Fresquez et al. (1990) who found a significant increase in agricultural productivity when biosolids were applied to a degraded grassland,
- Dorn et al. (1985) who found the absence of human or animal health effects from land application of biosolids, and
- Pillai et al. (1996) who failed to find airborne transport of microbial pathogens from land application of biosolids.

Overall, these deficiencies seriously detract from the validity of the CWMI document.

3. OVERVIEW OF THE TWELVE ISSUES

The heart of the Cornell document involves 14 issues that the authors use to support their premise that the 503 Rulemaking process was not health protective (document pp. 14-30). As noted above, two of these issues have no scientific components and cannot be dealt with in the context of a scientific peer review. The remaining twelve issues are presented in the remainder of this section along with a brief response to each based on our detailed analysis of the issue. The detailed analyses, along with citations to the scientific literature, are given in Section 4.

3.1 Allows Pollution to Reach Maximum "Acceptable" Level (Issue No. 1, page 14)

Issue: The Cornell document states that the 503 Rule allows chemicals to be added to soil up to a particular limit. The CWMI feels that chemicals in biosolids will be added to soil until that limit is reached. The CWMI feels that there is insufficient information known about chemical residuals in biosolids to set numerical standards based on levels that are considered to be safe. Because of this, CWMI advocates alternative policy approaches such as application of the precautionary principle.

[3] Some of this information will be presented in Section 4.5 of this peer review.

Response: Regulatory agencies in the United States and abroad including the EPA, Agency for Toxic Substances and Disease Registry (ATSDR), and the World Health Organization (WHO) routinely set regulatory standards on the basis of risk assessments. These risk assessments contain numerous conservative (health-protective) assumptions to assure that public health and the environment will not be harmed by the application of the standard. The metals regulated by the 503 Rule are some of the most well-studied chemicals known to science. The ATSDR has published extensive toxicological profiles for each of these chemicals, EPA has published ambient water quality and drinking water criteria documents, and WHO has published International Programme for Chemical Safety (IPCS) monographs for these chemicals. In addition to these summaries by regulatory and public health agencies, there is a vast scientific literature covering toxicology, epidemiology, chemistry, and environmental fate of these substances. There is simply no truth to CWMI's contention that there is too little known about the behavior of these chemicals in the environment to safely regulate their use in biosolids. Additionally, there is no evidence that metals from biosolids are accumulating in soil until limits published in the 503 Rule are reached. Indeed, with the success of industrial pretreatment and pollution prevention programs, the levels of metals in biosolids are declining.

3.2 No Safety or Uncertainty Factors (Issue No. 2, page 14)

Issue: The Cornell document states that "many risk assessment-based standards divide calculated numbers" by numerical safety factors ranging from 2 to 1,000. The Cornell document concludes that EPA was not being sufficiently protective in developing the 503 Rule numerical standards because of its failure to apply safety factors.

Response: The Cornell document is in error on two counts. First, EPA did use safety factors in its analysis, ranging from a factor of 3 to 1,000, depending on the chemical involved. Second, EPA also selected a sufficient number of high-end exposure assumptions that its analysis is sufficiently conservative to protect public health.

3.3 Evaluates Each Pathway Separately, Not Accounting for Multiple Pathways of Exposure or Synergy (Issue No. 3, page 15)

Issue: The Cornell document criticizes EPA for evaluating exposure pathways separately rather than accounting for multiple pathways or synergy.

Response: There is no evidence in the scientific literature of synergy among the chemicals evaluated by EPA in the 503 Rule. Standard regulatory practice is to consider the effects of chemicals to be additive if the toxic effects that they can cause are the same. Since the effects potentially caused by the 503 Rule metals are all different, there is no need for additivity. With respect to exposure

pathways, EPA used the "limiting pathway" concept. In most risk assessments, it is found that substantially higher risks are associated with a particular pathway, known as the limiting pathway. In the 503 Rule, EPA selected the limiting pathway (i.e., the pathway that dominated the risk) for the metals. The limiting pathway was a child ingesting biosolids for 5 metals, plant phytotoxicity for 4 metals, and an animal ingesting feed for one metal. Although organics were not included in the final 503 Rule, they were included in the risk assessment. There was a wide variety of limiting pathways for organics including adults consuming fish and animals in addition to the ones evaluated for metals.

3.4 Calculates Cancer Risk of 1-in-10,000 vs. 1-in-1,000,000 (Issue No 4. page 15)

Issue: Many environmental standards or criteria are based on the attainment of a target cancer risk level. Others, although not explicitly based on a target risk level, are associated with some level of cancer risk. The Cornell document criticizes EPA for selecting a risk level of 1-in-10,000 rather than a risk of 1-in-1,000,000, which the Cornell document states EPA uses for drinking water regulations.

Response: The Cornell authors either have misunderstood the concept of target risks in standard setting or have deliberately chosen to misrepresent the evidence. There are no absolute standards for cancer risk in the federal government. Risks associated with various standards span many orders of magnitude from greater than 1-in-100 to 1-in-10,000,000. The risk range cited by the Cornell document is for the Superfund program (40 CFR 300) and is not relevant to the 503 Rule. Many factors in addition to absolute target risks are considered by regulatory agencies in setting standards. EPA's selection of 1-in-10,000 for the 503 Rule was based on evidence from independent studies that showed minimal risk associated with biosolids use and disposal. Contrary to the contentions of the Cornell document, the risks associated with drinking water standards actually range from slightly higher than 1-in-1,000 to slightly higher than 1-in-1,000,000 with most being between 1-in-10,000 to 1-in-100,000.

3.5 Soil Ingestion Rate (Issue No. 5, page 15)

Issue: The exposure pathway based on inadvertent ingestion of soil is the most restrictive pathway for 5 of the metals regulated by the 503 Rule. Because of this, the risk assessment for this pathway is a critical element of the 503 Rule risk assessment. The Cornell document criticizes EPA for using a soil ingestion rate of 200 mg/day for children and for failing to include adult soil ingestion. The Cornell document also alleges that soil ingestion rates peak in teenage years.

Response: The Cornell document ignores most of the scientific and regulatory literature on this topic. The soil ingestion rate of 200 mg/day is a standard highly conservative value universally used by EPA and public health agencies.

Research has shown that this value may be an over-estimate of actual soil ingestion rates by up to an order of magnitude. EPA was fully justified in selecting a child because the combination of exposure factors including body weight, intake rate, frequency and duration produces a substantially greater exposure than that for an adult. There has been no information published that supports Cornell's contention that soil ingestion peaks during teenage years.

EPA also decided not to account for the bioavailability of metals ingested with soil, which would have reduced risks and increased the numerical standards associated with the 503 Rule. Recent data on arsenic, for example, suggests that accounting for bioavailability would increase the pollutant concentration limit from 41 mg/kg-biosolids to over 100 mg/kg-biosolids.

3.6 Underestimates Pollutant Intake Through Food (Issue No. 6, page 16)

Issue: The Cornell document alleges that EPA underestimates exposure to metals in food crops grown on biosolids-treated soil due to a number of assumptions made by EPA in the 503 Rule risk assessment. Cornell specifically criticizes the vegetable consumption rate and cadmium uptake factors. CWMI presents alternative results supporting a cadmium limit of 1.5 mg/kg.

Response: As with many of the issues in the Cornell document, the authors do not present any actual data or calculations. For this issue, although they criticize EPA's food consumption values, they do not present any alternatives, nor do they present any calculations supporting their recommended cadmium limit. Contrary to the assertions of the document, EPA was highly conservative in the risk assessment for ingestion of vegetables containing cadmium. Indeed, the analysis performed by EPA for the 503 Rule risk assessment is as conservative, if not more so, than other risk assessments performed by EPA.

3.7 RfD for Arsenic of 0.0008 mg/kg/day vs. 0.0003 or less (Issue No. 7, page 19)

Issue: The Cornell document states that EPA should have used a risk reference dose (RfD) of 0.0003 mg/kg-day for arsenic rather than 0.0008 mg/kg-day.

Response: Cornell produced no scientific evidence to support this contention. EPA (2001) clearly states that "strong scientific arguments can be made for various values within a range of 2 or 3 of the currently recommended RfD value, i.e., 0.1 to 0.8 µg/kg/day" (0.0001 to 0.0008 mg/kg-day). The toxicological data suggest that even 0.0008 mg/kg-day is extremely protective. For example, the Agency for Toxic Substances and Disease Registry (ATSDR) states that sensitive individuals in exposed populations begin to display one or more signs of mild arsenic toxicity at 0.02 mg/kg-day, or 25 times higher than the reference dose used by EPA in the 503 Rule risk assessment.

3.8 Many Pollutants Not Regulated or Monitored (Issue No. 8, page 20)

Issue: The Cornell document criticizes the 503 Rule for regulating only a small number of contaminants that are potentially present in biosolids. CWMI was particularly critical of the omission of boron, fluoride, synthetic organic chemicals, and radionuclides from the list of chemicals regulated under the 503 Rule.

Response: EPA and NYDEC discussed this issue in depth. The Cornell document does not present any evidence that any of these substances are present in biosolids at levels of significance to human health or the environment. Industrial pretreatment and pollution prevention programs serve to keep many materials out of municipal wastewater. Most synthetic organic substances are biodegradable. The biological and chemical processes that occur in such processes as activated sludge, sludge digestion, and composting are highly effective at removing synthetic organics. Use restrictions in the 503 Rule allow for additional biodegradation to occur.

3.9 Ground and Surface Water Calculations Assume Large Dilution/Attenuation (Issue 9, page 23)

Issue: The Cornell document alleges that EPA has underestimated the potential impact of biosolids on surface water and groundwater by over-estimating the degree of dilution or attenuation that metals will undergo in the environment before they reach a water body.

Response: *Dilution and attenuation are complex factors that need to account for* a variety of chemical and physical processes. Research has shown that there is little propensity for metals to migrate from land-applied biosolids into water bodies. The concentrations of metals in soil from the application of biosolids are well below those used by EPA to identify the potential for water contamination. In addition, best management practices (BMPs) are required by the 503 Rule to address this. These include such institutional controls as setbacks, buffers and soil type requirements.

3.10 Not Protective of Agricultural Productivity (Issue 10, page 25)

Issue: The Cornell document alleges that EPA's risk assessment for the 503 Rule will result in phytotoxicity, adverse impacts on soil micro-organisms, and negative impacts on animal health.

Response: EPA performed a comprehensive analysis of phytotoxicity, soil microorganisms, and impacts on livestock. The phytotoxicity pathway involved two separate approaches. The most conservative of these approaches was selected as the final value for this pathway. EPA also evaluated two pathways involving animal exposure (pathways 6 and 7) and performed a separate assessment of impacts on soil microorganisms. These analyses were highly

protective. Phytotoxicity was the basis of the pollutant limits for chromium, copper, nickel, and zinc. Animal impacts were the basis of the pollutant limits for molybdenum. A screening analysis of U.S. biosolids performed for this peer review confirms that currently generated biosolids are safe with respect to agricultural productivity (see Section 4.10 for details). This view is supported by research results that show biosolids application increases productivity (e.g., Samaras and Tsadilas 1999) rather than decrease it as alleged by CWMI.

3.11 Inadequate Assessment of Pathogen Risks (Issue 11, page 28)

Issue: The Cornell document claims that EPA did not adequately assess risks associated with pathogens in biosolids. The document further asserts that the most likely route of human exposure occurs through leaching of pathogens to groundwater.

Response: The Cornell document ignores both the fact that EPA opted for technology-based standards for pathogens and also the large body of scientific knowledge that has accumulated on the topic of pathogens. Contrary to the assertions of the Cornell document, EPA has performed a significant amount of risk assessment regarding pathogens associated with biosolids. Both EPA and independent researchers have addressed the question of groundwater contamination. These researchers reached the conclusion that the health risk to humans from exposure to microbial pathogens of fecal origin deposited in well-designed and operated sanitary landfills is below levels currently considered to be acceptable for the protection of public health. Since landfilled sludge has pathogen levels many orders of magnitude higher than Class A or B biosolids, this statement is likely to also apply to land applied biosolids. The Cornell document also ignored the large body of scientific knowledge regarding pathogens in Class B biosolids that leads to the conclusion that the 503 Rules are health protective against the effects of pathogen exposure.

3.12 Ecological Impacts Inadequately Assessed (Issue 12, page 25)

Issue: The Cornell document alleges that EPA's rulemaking process was deficient in its consideration of ecological impacts. The document further claims that ecological risk may be more important than human health risk for some contaminants.

Response: EPA calculated risks to plants, animals, and soil microorganisms in the 503 Rule risk assessment. These calculations involved determining the threshold pollutant intake for the most sensitive species in addition to bioaccumulation and bioconcentration as appropriate. A conservative screening analysis performed as part of this peer review using a variety of ecotoxicological benchmarks demonstrates that U.S. biosolids are safe with respect to ecological impacts (see Section 4.12 for details).

3.13 Other Issues Raised in the Cornell Document

The Cornell document raises numerous other issues that cannot be addressed due to time and length constraints. One issue that is highly significant is CWMI's comparison of metal standards from the 503 Rule with other metals standards in soil (pp. 8-11 and 32). We conducted a general analysis for all of the 503 Rule metals for which data were readily available and a detailed analysis for arsenic and lead. The results of this analysis show that the levels of metals in biosolids are comparable to those in fertilizers and other soil amendments. In addition, a detailed analysis of CWMI's presentation for specific chemical elements shows that there are numerous scientific errors in the Cornell document regarding these elements and that the levels in the 503 Rule are health protective when the appropriate comparisons are made (see Section 4.14 for details).

4. DETAILED ANALYSIS OF THE TWELVE ISSUES

4.1 Allows Pollution to Reach Maximum Acceptable Level

Many of the topics discussed in this and ensuing sections are concerned with concentrations of metals in soil that has been land treated with biosolids. In order to be able to evaluate these questions, it is necessary to have a reliable dataset for concentrations of metals in soil following land application of biosolids. The concentration of metals in biosolids amended soils may be calculated by the following equation (EPA 1999):

$$\frac{mg\,X}{kg\,soil} = \frac{mg\,X}{kg\,biosolids} \times AR\left(\frac{kg}{ha}\right) \times \frac{ha}{2x10^6\,kg\,soil}$$

where

X represents an individual metal,
AR = application rate (kg/ha), and
ha/2x10^6 kg soil = conversion factor.

This equation assumes that the soil has a density of 1.33 g/cm^3 and conservatively assumes that the tilling depth is 15 cm (about 6 inches) in addition to an application rate of 3 tons per acre (EPA 1995b). For a more typical tilling depth of 20 cm (8 inches), the resulting concentrations would be reduced by 25%. This equation was used to calculate resulting concentrations of metals in soils hypothetically amended with biosolids based on average concentrations of metals in biosolids reported in the literature (WEF 2001, Lue-Hing et al. 1999). The concentrations of the metals that we calculated using this equation and the accompanying assumptions are shown in Table 2.

Table 2
Concentrations of Metals in Soils following Land Application (mg/kg)

Metal	Average Concentration in U.S. Biosolids	Average Soil Concentration (15 cm tilling depth)	Average Soil Concentration (20 cm tilling depth)
Arsenic	5.8	0.21	0.16
Cadmium	6.7	0.024	0.018
Chromium	111	0.21	0.16
Copper	624	2.3	1.7
Lead	122	0.44	0.33
Mercury	3.6	0.013	0.01
Molybdenum	15	0.054	0.0405
Nickel	50	0.18	0.14
Selenium	5.7	0.02	0.015
Zinc	1,016	3.7	2.8

A simple example will show that it is virtually impossible for application of biosolids to reach the levels of concern in the 503 Rule risk assessment. Taking cadmium as an example, the 503 Rule risk assessment acceptable soil concentration is 19.7 mg/kg (EPA 1995a). If the background soil concentration is taken to be 0.2 mg/kg as per EPA (1995a), then 19.5 mg/kg can come from the application of biosolids. At the rate of 3 tons biosolids applied per acre, it would take 812 years of application at a tilling depth of 15 cm and 1,100 years of application at a tilling depth of 20 cm to reach the limiting value of 19.7 mg/kg. In reality, this will be even substantially longer due to both the decline of metals in biosolids and the fact that biosolids will not be applied at the rate of 3 tons per year for hundreds of years anywhere. Due to the success of industrial pre-treatment and pollution prevention programs, the average concentration of cadmium in U.S. biosolids dropped from 69 mg/kg-dry weight (mg/kg-dw) in 1979 to 6.4 mg/kg-dw in 1996; concentrations in Canadian biosolids dropped from 35 mg/kg-dw in 1981 to 6.3 mg/kg-dw in 1995 (Webber and Nichols 1995, Lue-Hing et al. 1999). If these trends continue, the resulting soil concentrations will be proportionately lower. Further, the application of biosolids is nutrient limited according to terms and conditions of land application permits in addition to the agronomic application rates required by the 503 Rule. A typical application is either nitrogen or phosphorous limited. The biosolids in our example contain about 2.5 lb organic-N per 100 lb biosolids. Over a period of repeated applications, there will be accumulation of nitrogen and/or phosphorous in the soil. With our example, immediately after application, there will be 150 lb/acre organic-N in the soil. However, after three years, there will still be 103 lb/acre organics-N assuming typical rates of mineralization and uptake. Thus, it will be necessary at some point to drastically limit or even cease application of biosolids to prevent runoff or infiltration of soluble nutrient species.

The other point that the Cornell document seems to be making regarding this issue is that there is insufficient information known about these chemicals to regulate them with any certainty. The metals regulated by the 503 Rule are some of the most-studied chemicals known to science. The ATSDR has published extensive toxicological profiles for each of these chemicals, EPA has published ambient and drinking water criteria documents, and the WHO has published International Programme for Chemical Safety (IPCS) monographs for these chemicals. In addition to these summaries by regulatory and public health agencies, there is a vast scientific literature covering toxicology, epidemiology, chemistry, and environmental fate of these substances. Risk assessments for the management of these chemicals are routinely performed by the EPA, OSHA, FDA, ATSDR, and the Consumer Product Safety Commission (CPSC) using this information. For example, risk assessments for cleanup of Superfund sites, development of ambient water quality standards, and incinerator permits under the Resource Conservation and Recovery Act are routinely performed using much of the same information used by EPA in the 503 Rule risk assessment.

As an example, ATSDR (1999) has summarized the regulatory and toxicological information for cadmium. This summary reports that ATSDR has derived a chronic oral minimal risk level for cadmium, that cadmium is regulated under Section 112 of the Clean Air Act, that OSHA and NIOSH have developed permissible exposure limits for cadmium, EPA has developed drinking water maximum contaminant levels and ambient water quality criteria for cadmium, EPA has promulgated fish advisories for cadmium, and that FDA has regulated cadmium in ceramics for food use. All in all, ATSDR found over 100 risk-based standards or criteria for cadmium at the national level in addition to numerous other international and state criteria and standards. All of these standards were developed using risk assessment methods and information similar to, if not identical to, that used by EPA for the 503 Rule. There is simply no truth to CWMI's contention that there is too little known about the behavior of these chemicals in the environment to safely regulate their use in biosolids.

4.2 No Safety or Uncertainty Factors

EPA assures the conservatism of risk assessments by using both high-end exposure factors and by using explicit safety factors. EPA uses safety factors known as uncertainty factors explicitly in the development of risk reference doses. The safety factors for the metals in the 503 Rule range from a factor of 3 to a factor of 1,000, with an average value of about 220. These values are in the same range as those used by the Dutch authorities cited by the Cornell document (page 14), thus the criticism that EPA did not use safety factors is erroneous and unwarranted.

In addition to explicit safety factors, EPA uses implicit safety factors by selecting exposure factors that are unrealistically conservative and at the high end of their possible range. As we show in Section 4.5, EPA has selected a soil ingestion

rate that is about 8.3 times higher than the actual median value. This represents an additional safety factor of 8.3 for the child soil ingestion pathway added to the explicit safety factors from the RfDs.

4.3 Evaluates Each Pathway Separately, Not Accounting for Multiple Pathways or Synergy

This issue was explicitly addressed by EPA in the 503 Rule risk assessment (EPA 1995a). EPA noted that there was no evidence for synergy among the chemicals regulated under the rule. Standard risk assessment practice (EPA 1989a) is to evaluate chemicals individually unless there is toxicological evidence to show that they interact. At the low levels at which biosolids-derived chemicals may be found in the environment, there is little potential for synergy (where the effect of the combination of chemicals is greater than a merely additive interaction) or antagonism (where the effect of the combination is less than an additive effect). The toxicological effects of chemicals are considered to be additive if they produce the same health endpoint or act on the same target organ. The health endpoints for the metals regulated by the 503 Rules are shown in Table 3:

Table 3
Health Endpoints for 503 Rule Metals

Metal	Health Endpoint
Arsenic	Hyperpigmentation, keratosis
Cadmium	Proteinuria
Copper	Vomiting, stomach cramps
Mercury	Autoimmune effects
Lead	Cognitive dysfunction
Selenium	Selenosis
Zinc	Decrease in erythrocyte superoxide dismutase

This information shows that these metals all have different health endpoints and, thus, their effects are not additive.

EPA did not add exposure pathways because EPA relied on the concept of the limiting pathway. Experience has shown that one or two exposure pathways produce the most conservative (health protective) results in risk assessment. The most conservative pathway is known as the limiting pathway; other exposure pathways will produce risk assessment results that are much less conservative. For metals, the most conservative and, therefore, limiting human exposure pathway is direct ingestion of soil. For example, the risks associated with dermal contact with arsenic in soil are 10.5 times lower than the risks associated with ingestion and the risks associated with inhaling arsenic in dust coming from soil are 1,400 times lower than the risks associated with ingestion. In this case, soil ingestion is the limiting pathway. Adding dermal contact and inhalation would not

have a noticeable effect on a soil criterion developed on the basis of soil ingestion only.

4.4 Calculates Cancer Risk of 1-in-10,000 vs. 1-in-1,000,000

Many environmental or occupational standards for exposure to chemicals are associated with a certain level of cancer risk. In some cases, the risk level is explicitly defined by a regulation. For example, in the federal Superfund program, a risk range from 1-in-10,000 to 1-in-1,000,000 is specified. This is known as a target risk. In other programs such as drinking water, the standard is developed on the basis of other factors and the cancer risk is calculated on the basis of the chemical residual remaining after implementation. This is known as residual risk. The drinking water program, for example, does not use a target risk. Rather standards are set on the basis of technical feasibility and other factors in addition to health concerns.

Sadowitz and Graham (1995) surveyed risk levels associated with various federal regulations. They found a wide range of target and residual risks. The Nuclear Regulatory Commission (NRC) regulates exposure to the general public with a lifetime cancer risk of about 3.5-in-1,000 and lifetime cancer risk to workers at greater than 1-in-100. The Occupational Safety and Health Administration (OSHA) generally uses a risk of 1-in-1000 to regulate worker exposure to potential carcinogens. EPA target risks often range from 1-in-10,000 to 1-in-1,000,000, however, residual risks may be substantially higher. An exhaustive survey conducted by Rhomberg (1996) for the President's Commission on Risk Assessment and Risk Management confirmed the findings of Sadowitz and Graham. Rhomberg found residual and target risks ranging from roughly 1-in-1,000 to 1-in-10,000,000 for various federal regulations.

Because the Cornell document focused on cancer risks associated with drinking water standards, we evaluated these in greater detail. Both drinking water standards and cancer unit risks were obtained from EPA for a variety of chemicals regulated in drinking water. These values were then used to calculate residual risk. The results are shown in Table 4.

Based on this analysis, the residual risk associated with drinking water standards ranges from 1-in-1,000 to slightly higher than 1-in-1,000,000. Most standards were associated with residual risks ranging from 1-in-10,000 to 1-in-100,000. No standards were found that have a 1-in-1,000,000 risk as asserted by the Cornell document.

Table 4
Residual Risks of Drinking Water Standards

Chemical Name	Drinking Water Standard (mg/L)[4]	Cancer Unit Risk (L/mg)[5]	Residual Risk
Arsenic	0.05	0.05	2.5-in-1,000
Benzene	0.005	0.00044	2.2-in-1,000,000
Benzo(a)pyrene	0.0002	0.21	4.2-in-100,000
Chlordane	0.002	0.01	2-in-100,000
Dibromochloromethane	0.08[6]	0.0024	1.9-in-10,000
Hexachlorobenzene	0.001	0.046	4.6-in-100,000
Pentachlorophenol	0.001	0.003	3-in-1,000,000
Toxaphene	0.003	0.032	9.6-in-100,000
Vinyl chloride	0.002	0.021 to 0.042	4.2-in-100,000 to 8.4-in-100,000

4.5 Soil Ingestion Rate

There is a voluminous amount of scientific literature on the question of soil ingestion rates. The Cornell document authors, however, chose to select one published study, one state regulatory document, and one unpublished European document as substantiation of their claim that EPA has not been sufficiently conservative in its application of a 200 mg/day soil ingestion rate. In actuality, EPA's analysis was highly conservative both with respect to its use of soil ingestion rates and its decision to not include bioavailability in the soil ingestion analysis.

EPA (1997) reviewed about 20 soil ingestion studies that had been reported in the literature. They concluded that the average soil ingestion rate for children was 100 mg/day and that risk assessors could use 200 mg/day *as a conservative estimate*. EPA also concluded that approximately ½ of this ingestion came from indoor exposure and ½ came from outdoor exposure. By six years of age, the total (indoor and outdoor) exposure had declined to 22 mg/day and above six years of age, EPA concluded that the total ingestion rate was 20.4 mg/day. There was no evidence to support the contention of the Cornell document that soil ingestion increased for teenagers.

Recently, Stanek et al. (2001) reviewed the overall scientific evidence on soil ingestion rates for children. Their analysis included several new studies that had

[4] Source of drinking water standards: http://www.epa.gov/safewater/mcl.html.
[5] Source: http://www.epa.gov/iris.
[6] As total trihalomethanes. This standard takes effect in January 2002.

been published since the EPA (1997) review. Stanek et al. (2001) concluded that the median soil ingestion rate for young children was 24 mg/day and the 95th percentile soil ingestion rate was 91 mg/day. This analysis confirms that EPA was highly conservative in selecting 200 mg/day as a soil ingestion rate for children.

The Cornell document criticizes EPA for not including adults as receptors in the soil ingestion pathway. In reality, adults are exposed much less than children due to lower soil ingestion rates. In addition, the average daily dose to an adult is substantially lower than the dose to a child because the adult's body weight is substantially greater. Considering only standard EPA default exposure factors (child soil ingestion of 200 mg/day, adult soil ingestion of 50 mg/day, child body weight of 16 kg, adult body weight of 70 kg), a child's exposure for a non-carcinogen will be 18 times greater than an adult's exposure. Thus, inclusion of an adult in this pathway would not have added to EPA's assessment since the child's exposure was much greater and results in more restrictive standards.

The Cornell document also failed to acknowledge that EPA did not include bioavailability in its analysis of soil ingestion. When soil containing metals is ingested, most of the metals are not absorbed into the body but rather are eliminated in the feces. The fraction that is absorbed is known as the bioavailable fraction. Only bioavailable metals exert toxic effects. A substantial amount of data has been published on the bioavailability of arsenic, cadmium, chromium, copper, mercury and lead (Hrudey et al. 1996). Whereas EPA assumed that the metals were 100% bioavailable, this research clearly shows that this is a significant over-estimate. For example, recent experiments on primates (Roberts 2001) show that the average arsenic bioavailability from soil is less than 30%. The numerical pollutant limits set by the 503 Rule risk assessment are linearly proportional to bioavailability. The most recent results for arsenic could increase the arsenic concentration limit in the 503 Rule from 41 mg/kg-biosolids to over 100 mg/kg-biosolids.

4.6 Underestimates Pollutant Intake Through Food

The Cornell document raised several issues regarding food consumption. These included an assertion that EPA underestimated food consumption rates and soil-plant uptake factors. The focus of the issue was on cadmium. Without presenting its assumptions or calculations, Cornell concluded that the pollutant application rate limit for cadmium in biosolids should be 1.5 kg per hectare of land (kg/ha) compared to the cumulative pollutant loading rate (CPLR) value of 39 kg/ha calculated by EPA.[7]

A detailed analysis of the parameters used by EPA in the 503 Rule risk assessment shows that CWMI's contentions are erroneous. EPA assessed risk

[7] Note that the CPLRs in kg/ha are numerically equivalent to the 503 Rule risk assessment pollutant concentration limits in mg/kg (EPA 1995a).

to a typical individual (pathway 1) and a "highly exposed individual" (HEI) (pathway 2). The HEI was intended to represent a subsistence gardener who grows a majority of his or her own diet in biosolids-amended soil. This individual represents less than 1 percent of the U.S. population (Ryan and Chaney 1993). Other conservative assumptions used by EPA for this pathway include:

- Assumption that plants took up cadmium from soil even when none was observed in actual studies,
- Use of a linear response slope for plant uptake from soil,
- Inclusion of acidic pH data,
- Assumption that an individual derives 37% of potatoes and 59% of vegetables from a backyard garden grown on biosolids- amended soils,
- Bioavailability (relative effectiveness) of 100%,
- Safety factor of 10 for the cadmium risk reference dose, and
- Assumption that home-grown vegetables are ingested 365 days per year.

These assumptions are considerably more conservative than those used in other risk assessments, both within and outside of EPA. Ryan and Chaney (1993) demonstrate that the use of linear response factors could result in an over-estimate of risk by as much as a factor of 20. Current EPA risk assessment practice (EPA 1998) is to assume that an individual obtains 20% of vegetables from his or her own garden. The oral bioavailability of cadmium from food is quite low (Hrudey et al. 1996). Depending on the chemical species and the exact matrix, cadmium bioavailability may range from 0.2% to 8%. If the bioavailability from biosolids is substantially lower than that assumed in derivation of the RfD, this could be a substantial over-estimate of risk. The values used for vegetable consumption are consistent with those used in other EPA risk assessments (EPA 1997a, EPA 1998). EPA, however, typically assumes that a child eats at home 350 days per year rather than 365 days per year (EPA 1997a). Taken as a whole, it may be easily seen that EPA's risk assessment was highly conservative and designed to protect over 99% of the population. This is directly contrary to CWMI's allegations regarding EPA's level of protectiveness.

The numerical standard for cadmium developed under the 503 Rule is considerably more conservative and health-protective than that used by EPA elsewhere. Depending on the tillage depth, the CPLR standard of 39 kg/ha translates into cadmium soil concentrations ranging from 15 to 20 mg/kg. EPA Region III has calculated risk-based concentrations (RBCs) to be used in decision-making at Superfund sites (EPA 2001b). The cadmium level for residential exposure is 78 mg/kg, substantially higher than the 503 Rule standard. In other contexts, EPA uses a health-based soil cadmium concentration of 70 mg/kg for a residential cleanup screening level and 900 mg/kg for an occupational screening level. The limiting pathway for the calculation of these standards was ingestion of soil, just as in the 503 Rule risk assessment.

The pollutant application rate limiting value of 1.5 kg/ha advocated by Cornell could lead to the absurd scenario where biosolids with cadmium levels less than natural background could not be applied. If 1.5 kg/ha is tilled to a 15 cm depth, the resulting soil concentrations would be 0.75 mg/kg; if tilled to a 20 cm depth (*viz* EPA 1998), the resulting concentration would be 0.56 mg/kg. These values are considerably lower than those found in the natural environment. For example, Kabata-Pendias and Pendias (1992) report cadmium levels in urban gardens in the U.S. to range from 0.02 to 13.6 mg/kg and cadmium in soils in the vicinity of highways to range from 1 to 10 mg/kg. It is clearly contrary to sound public policy to prohibit the application of substances that contains levels of a chemical less than those present due to natural causes.

4.7 RfD for Arsenic of 0.0008 mg/kg/day vs. 0.0003 or Less

The risk reference dose (RfD) is premised on the assumption that thresholds exist for toxic effects of chemical substances. In general, the RfD is an estimate of daily exposure to the human population including sensitive subgroups that is likely to be without appreciable risk over a lifetime.

The RfD for arsenic is based on the ability of arsenic to cause skin diseases such as hyperpigmentation and keratosis at high doses. Toxicologists generally agree that skin effects are the most sensitive health endpoint for arsenic. EPA (2001a) used data from a 1968 study conducted in Taiwan to derive a reference dose of 0.0003 mg/kg-day by applying a safety factor to a no adverse effect level of 0.0008 mg/kg-day. Other studies considered by EPA reported similar no adverse effect levels. When the proposed RfD was considered by EPA's Risk Assessment Council (RAC), it was concluded that any value within the range from 0.0003 mg/kg-day to 0.0008 mg/kg-day could be used for the RfD (Abernathy and Dourson 1994, EPA 2001a). Thus, EPA's Office of Water was fully justified in the value that it used in the 503 Rule risk assessment.

Aside from the appropriateness of the regulatory decision made by EPA, there is a substantial body to evidence to show that an RfD of 0.0008 mg/kg-day is safe (ATSDR 1989, 2000, NAS/NRC 2001). ATSDR (1989) notes that some people can ingest over 0.15 mg/kg-day without any apparent ill-effects while more sensitive individuals in exposed populations often begin to display one or more of the characteristic signs of arsenic toxicity at oral doses around 0.02 mg/kg-day. ATSDR (1989) continues to state that effects are usually mild at this level but become more severe as the doses increase.

ATSDR (2000) summarized numerous studies on the dermal effects of arsenic in humans. In this study, ATSDR evaluated both no observed adverse effect levels (NOAELs) and lowest observed adverse effect levels (LOAELs). As their names imply, NOAELs are doses at which adverse health effects are not seen and LOAELs are the lowest doses at which adverse health effects may be seen. ATSDR's data are summarized in Table 5.

Table 5
Toxicological Thresholds for Arsenic (ATSDR 2000)

ATSDR Study Number	Duration of Exposure	NOAEL (mg/kg-day)	LOAEL (mg/kg-day)
84			0.032
85	4 years		0.1
86			0.014
87	12 years		0.02
88	11-15 years		0.01
89	continuous	0.0004	0.022
90	1-11 years		0.046
94	3-7 years		0.05
95	2-6 years		0.08
96			0.014
97	1-20 years		0.06
98		0.0016	0.009
99	10 years		0.00065
102	0.5-14 years		0.05
103	15 years		0.03
104		0.004	0.005
105	3-22 years		0.05
106	15 years		0.05
109	28 months		0.06
110	> 5 years	0.0009 M/0.001 F	
114	>45 years	0.0008	0.014
117	16 months		0.1
118	12 years	0.015	
119	30-33 years		0.015
120			0.063

M = males; F= females.

These studies all pertain to long-term exposure of humans to arsenic including sensitive subgroups and children. There are numerous other studies of shorter duration and in other species that corroborate these results. These data all appear to have been ignored by the Cornell document authors. As can be seen from Table 5, the effects of exposure to arsenic have never been seen at the level of 0.0003 mg/kg-day advocated by Cornell. Indeed, quite a few studies show that there are no effects at these levels.

Based on both the regulatory and toxicological evidence, EPA was fully justified in its choice of 0.0008 mg/kg-day as a reasonable and protective RfD for arsenic.

4.8 Many Pollutants Not Regulated or Monitored

This is an issue that EPA explicitly considered in development of the 503 Rule. EPA has undertaken a substantial amount of investigation regarding organic chemicals in biosolids. On the basis of national surveys, EPA originally identified 18 organic chemicals or families of chemicals that could be significant in biosolids. These chemicals were evaluated in a risk assessment that involved the calculation of hazard indices for 13 pathways. On the basis of these calculations, 10 chemicals or families of chemicals were selected for further analysis. These chemicals were classified generally as pesticides, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs) and chlorobenzenes. EPA found through a detailed evaluation that PAHs and chlorobenzenes in biosolids were without significant risk. In a review of over 20 years of land application data, Chaney (1990) reported that, except for carrot peels, there is little evidence for plant uptake of PCBs, the pathway that EPA had identified for further investigation. The pesticides in biosolids applied to land are substantially lower than the pesticide concentrations that were applied in typical farming practice (Jones and Wild 1991).

Public comment recommended that certain pollutants proposed for evaluation under the 503 Rule that were banned or otherwise not available in the U.S. (e.g., aldrin, dieldrin, toxaphene, chlordane, DDT, and heptachlor) be deleted from the rule. In response to this comment, EPA re-evaluated all of the organic chemicals contained in the original proposal. In the final rule, EPA proposed to delete organic chemicals because they failed to meet one or more of the following criteria (EPA 1995a):

- The chemical had been banned or restricted or is no longer manufactured for use in the United States,
- The chemical is not present in biosolids at significant frequencies of detection (5%) based on a national survey, or
- The proposed limit for the chemical is not expected to be exceeded in biosolids.

CWMI has presented no additional information to suggest that there was a problem with EPA's analysis or that there is substantial new information.

Recent information (Verschueren 2001) demonstrates that organics are present in biosolids at low frequencies and sub-mg/kg quantities, if they are present at all. These analyses further support EPA's decisions regarding synthetic organic chemicals. Although a detailed evaluation of all the information available on organics in biosolids is beyond the scope of this peer review, an example is benzo(a)pyrene (BAP). Verschueren (2001) reports that the concentration of BAP in primary and digested sewage sludge ranges from 0.27 to 0.57 mg/kg. This may be compared to the proposed EU limit of 6 mg/kg in biosolids. If this material were land applied using the assumptions in Section 4.1, it would result in

a soil concentration of about one µg/kg (one part-per-billion). This may be compared to the normal background range of BAP in urban soil of 0.04 - 13 mg/kg (Bradley et al. 1994).

In addition to EPA, many other researchers have investigated the question of trace amounts of synthetic organic chemicals in biosolids (Davis et al. 1984, Drescher-Kaden et al. 1992, Jacobs et al. 1987, Lester 1983, Sweetman 1991, Smith 1991). The consensus of these researchers is that organic chemicals in biosolids applied to agricultural lands are not likely to cause significant environmental impact.

Most organic chemicals are biodegradable to some extent. The conditions present in wastewater treatment processes, especially activated sludge, digestion, and composting all accelerate biodegradation rates of organic chemicals. For example, chlorobenzene has a biodegradation half life of 7.9 days in activated sludge compared to 75 days in sediment and 81->539 days in soil (Verschueren 2001). Biodegradation continues after land application. For example, Angle and Baudler (1984) found that chemical mutagens[8] decreased rapidly starting 7 days after application due to the rapid degradation of synthetic organic compounds in the soil.

4.9 Ground and Surface Water Calculations Assume Large Dilution/Attenuation

The Cornell document states that EPA used inappropriately high dilution and attenuation factors for protection of groundwater, yet they do not present any evidence to show that groundwater contamination from metals in land-applied biosolids is a problem. The only citation that the document presents to support this contention is one to some materials produced by an author who is affiliated with the CWMI. Because of the lack of objectivity of the CWMI, this material must be viewed with caution.

Most metals are not highly water soluble and interact with natural constituents present in biosolids and soils to form low-solubility chemical species. These low-solubility species are not likely to migrate into groundwater or surface water under normal hydrologic conditions. For example, arsenic in biosolids is present in the form of arsenate which reacts with commonly occurring calcium and iron to form insoluble iron and calcium arsenates. The solubility of these complexes is too low to be of potential concern regarding potential contamination of water resources.

EPA (2001c) has developed a conservative set of soil concentrations, known as soil screening levels (SSLs) that are designed to be protective of groundwater. The metals regulated under the 503 Rule and for which EPA has developed

[8] Mutagens are chemicals that cause biological mutations. Many carcinogens and reproductive toxins are also mutagens.

SSLs are shown in Table 6 along with average soil concentrations following land application of biosolids. These data show that, even under the conservative assumptions associated with SSL development, the potential for groundwater impact by metals found in biosolids is negligible.

Table 6
Groundwater Protection SSLs and Soil Concentrations (mg/kg)

Metal	Average Soil Concentration (15 cm tilling depth)	Groundwater protection SSLs
Arsenic	0.21	1-29
Cadmium	0.024	0.4-8
Chromium	0.21	9.9E7-2E9
Mercury	0.013	0.1-2
Nickel	0.18	7-130
Selenium	0.02	0.3-5
Zinc	3.7	620-12,000

The results of these predictions are confirmed by research conducted in the laboratory and in the field. Chang et al. (1984) investigated the migration depths of cadmium, chromium, copper, nickel, lead and zinc from six years of land applied biosolids from a variety of soil types. Initially, the biosolids had been applied to a 15-cm depth. The results of their investigations showed no migration beyond 30 cm suggesting that, even after 6 years of application, only about 6 inches of migration had occurred. Berti and Jacobs (1998) also found no migration to depths greater than 15-30 cm in another study involving land application of biosolids.

Another study involved the long-term application of biosolids to agricultural soils for 20 years (Draeger et al. 1999). This study found that, even after high loading rates for 20 years, chromium and copper moved to depths of 45 cm (18 inches) and 60 cm (24 inches), respectively, with other metals migrating to a lesser degree. This study also found that biosolids application did not increase metal loadings in snow runoff. Draeger et al. (1999) concluded that the use of best management practices (BMPS) for land application of biosolids would result in no negative effect on surface or groundwater quality.

Thus, regardless of the dilution/attenuation factors (DAFs) used by EPA in the 503 Rule risk assessment, there is no evidence in the scientific literature that groundwater or surface water contamination is a significant issue for land application of biosolids.

4.10 Not Protective of Agricultural Productivity

EPA evaluated the impact on agricultural productivity as part of the 503 Rule risk assessment, however, CWMI did not acknowledge EPA's analysis. EPA performed a comprehensive analysis of phytotoxicity, toxicity to soil microorganisms, and impacts on livestock. The phytotoxicity pathway involved two separate approaches. The most conservative of these approaches was selected as the final value for this pathway. EPA also evaluated two pathways involving animal exposure (pathways 6 and 7) and performed a separate assessment of impacts on soil microorganisms. These analyses were highly protective. Phytotoxicity was the basis of the pollutant limits for chromium, copper, nickel, and zinc. Animal impacts were the basis of the pollutant limits for molybdenum. As is the case with most of the Cornell document, the CWMI did not present any alternative analysis or factual information to detract from the analysis presented by EPA.

We confirmed the validity of EPA's analysis by performing an independent search of the literature for numerical criteria and standards pertinent to agricultural productivity. Information regarding phytotoxicity, impact on earthworms, and impact on micro-organisms present in leaf litter was obtained from Oak Ridge National Laboratories (ORNL 1997). In addition, agricultural standards for chemicals in soil were obtained from Canada (Canadian Council of Ministers of the Environment or CCME) and the Netherlands (RIVN). The values obtained for the metals were then compared to average values for metals in biosolids-amended soils calculated in Section 4.1. This information is presented in Table 7.

Table 7
Comparison of Metals in Biosolids-Amended Soils to Agricultural Criteria and Standards (all in mg/kg)

Metal	Average Soil Concentration (15 cm tilling depth)	Earthworm Criteria	Soil microorganism criteria	Phytotoxicity criteria	CCME Criteria	RIVN Criteria
Arsenic	0.21	60	100	10	20	40
Cadmium	0.024	20	20	4	3	12
Chromium	0.21	0.4	10	1	750	230
Copper	2.3	50	100	100	150	190
Lead	0.44	500	900	50	375	290
Mercury	0.013	0.1	30	0.3	0.8	10
Molybdenum	0.054	--	200	2	5	<480
Nickel	0.18	200	90	30	150	210
Selenium	0.02	70	100	1	2	--
Zinc	3.7	200	100	50	600	720

The data presented in this table show that there are wide margins of safety between the actual levels in soil and the various conservative, screening-level standards and criteria that affect agricultural productivity. This corroborates EPA's analysis of this issue in the 503 Rule.

4.11 Inadequate Assessment of Pathogen Risks

There has been a substantial amount of confusion in the minds of stakeholders over EPA's position regarding pathogens in the 503 Rule. When developing environmental regulations, EPA often has the option to develop a risk-based regulation or a technology-based regulation. Risk-based regulations are based on the ability to calculate human health or ecological risks associated with exposure to a chemical, biological, or physical agent in the environment. Technology-based standards are typically prescriptive acts that ensure the protection of human health and the environment through the imposition of engineering practices. Best Available Technology (BAT) and Maximum Achievable Control Technology (MACT) are common technology-based regulations used by EPA in other programs. In some cases, such as the development of drinking water standards, the standards are a combination of risk-based and technology-based standards.

In the case of pathogens under the 503 Rule, EPA has performed a substantial amount of analysis and opted for technology-based standards (Girovich 1996). The objective of these standards is to ensure that the density of any residual pathogens in the biosolids is below the minimum infective dose when there is unrestricted contact between members of the public and the biosolids. Contrary to the claims made by the Cornell document authors, EPA has conducted a substantial amount of risk assessment research into pathogens in biosolids. In 1986, EPA published the results of a study concerning pathogen inactivation during aerobic digestion of wastewater sludge (EPA 1986). Subsequent research concerning viruses, pathogen survival, pathogen reduction, and pathogen risk assessment were subsequently published by EPA (EPA 1989b, 1991,1992, 1995c, 1999). Taken as a whole, these documents refute Cornell's allegation that there has been inadequate assessment of pathogen risks. The Cornell document did not acknowledge any of this research performed by and published by EPA. Last, it should be noted that there was also a long record of success with technology-based pathogen controls under the 257 Rules that were the predecessors of the 503 Rule.

The Cornell document cites an article by Straub et al. (1993) to support its contention that significant levels of pathogens are present in Class B biosolids. In fact, the information in the Straub et al. (1993) report leads to exactly the opposite conclusion. With respect to viruses, which are particularly targeted by the Cornell document (p. 29), Straub et al. (1993) report that there are between 10^2 and 10^4 enteric viruses per gram of primary sludge and approximately 300

viruses per gram of secondary sludge. Straub et al. (1993) further show that viruses undergo between a 1 and 3 log reduction by treatment for conversion into Class B biosolids. Thus, the levels of viruses are negligible at the time of land application. After land application, EPA (1995c) reports inactivation rate constants for viruses in soil that range from 0.0017 to 3.69 log/day. Smith and Farrell (1996) report that the absolute maximum survival time for viruses in soil is 6 months and a common maximum survival time is 3 months. Thus, even if a significant number of viruses were to be present in treated Class B biosolids, they would quickly be deactivated in the soil.

The potential for groundwater contamination by pathogens from biosolids and wastewater sludge has been addressed by various researchers (EPA 1995c, Straub et al. 1993, Haas et al. 1996). These reports clearly show that this route is not likely to be a problem. For example, Haas et al. (1996), discussing landfilling of raw fecal material with higher pathogen levels than Class B biosolids, concludes that, "even with conservative assumptions, the health risk to humans from exposure to microbial pathogens of fecal origin deposited in well-designed and operated sanitary landfills is below levels currently considered acceptable under U.S. drinking water regulations applicable to treated potable water supplies."

4.12 Ecological Impacts Inadequately Assessed

The Cornell document completely mischaracterized EPA's ecological impact assessment for the 503 Rule. On page 29, the Cornell document states that EPA addressed only the impact of copper on earthworms and of cadmium, lead and PCBs on shrews. In reality, EPA's ecological risk assessment was quite comprehensive. EPA (1995a) evaluated the impacts of biosolids on animals, plants, and soil microbes. EPA's evaluation of animals other than livestock included small herbivores and soil organisms.

Ecological issues are extremely complex. An objective analysis of land application of biosolids should include the ecological benefits of this practice along with any adverse ecological impacts. For example, biosolids are often used to restore sites that have been degraded by over-cropping or mining. The restoration provides habitat and forage for a variety of ecological communities that would not have existed without this restoration.

Although a complete ecological assessment is beyond the scope of this peer review, a simple screening analysis can be performed by comparing concentrations of metals that may be found in biosolids-amended soil to various ecological screening criteria that have been developed by different jurisdictions. The American Petroleum Institute (API) surveyed conservative ecological soil screening criteria from around the world. The range of criteria they found are shown in Table 8 along with average concentrations of metals found in U.S. biosolids.

Table 8
Comparison of Metals in Biosolids-Amended Soil to Screening Ecological Criteria (mg/kg)

Metal	Average Concentration in U.S. Biosolids	Average Soil Concentration (15 cm tilling depth)	Range of Ecological Soil Criteria
Arsenic	5.8	0.21	2-150
Cadmium	6.7	0.024	0.8-4500
Chromium	111	0.21	150-800
Copper	624	2.3	3-90,000
Lead	122	0.44	20-30,000
Mercury	3.6	0.013	0.1-1500
Molybdenum	15	0.054	2-254
Nickel	50	0.18	4-500
Selenium	5.7	0.02	0.81-100
Zinc	1,016	3.7	450-70,000

As these data show, the concentrations of metals in soils that have been treated with biosolids are too low to be of ecological significance. Also of interest is the fact that many pure biosolids are likely to have metals concentrations below ecological thresholds and would support viable communities even in the absence of soil incorporation. When taken in conjunction with the data regarding agricultural productivity presented in Section 4.10, there is no evidence to support CWMI's allegation of adverse ecological impacts from land application of biosolids.

4.13 Other Issues Raised in the Cornell Document

The Cornell document makes many comparisons of metal concentrations based on the 503 Rule with those found elsewhere. Comparisons are made to other regulations, soil concentrations, and calculated values. In many instances, the values presented by CWMI are simply erroneous; in other cases, only part of the picture was given, and in still other cases the relevant comparisons were not made.

Because biosolids are used as soil amendments, comparisons to other soil amendments are most relevant. Fertilizers, composts, and soil conditioners, especially those derived from natural sources, normally contain levels of trace metals that are equal to or higher than those found in biosolids. Cadmium may be used as an example. The average cadmium concentrations in biosolids are 6.3 mg/kg for Canada and 6.4 mg/kg for the United States (Webber and Nichols 1995, Lue-Hing et al. 1999). These values may be compared with the average

cadmium in phosphate fertilizers of 11 mg/kg (Mortvedt 1996) and the average for cadmium in home fertilizers of 5.85 mg/kg (EPA 1999). Ranges for cadmium in other fertilizer products (EPA 1999) are shown in Table 9.

Table 9
Cadmium Concentrations in Fertilizers

Fertilizer Type or Biosolids	Cadmium Concentration (mg/kg)
Rock Phosphates	10-42
NPK	<0.1-200
Organic fertilizers	0.3-15
Secondary nutrient/micronutrient	<0.6-2165
Liming materials	<0.2-8.1
Home products	0.05-56.5
Phosphate fertilizers	11 (average)
Home fertilizers	5.85 (average)
Biosolids (Canada)	6.3 (average)
Biosolids (U.S.)	6.4 (average)

Thus, it is apparent that there is little or no difference between cadmium concentrations in biosolids compared to other materials used in agriculture, including those approved for unrestricted home use. Similar data are available for the other metals regulated by the 503 Rule.

The CWMI was also extremely selective in their comparison of U.S. regulations to regulatory limits in other jurisdictions. For example, their comparison for mercury (Table 5) gives the impression that the U.S. is the least stringent (allows highest mercury concentrations) of the nations surveyed. A wider survey corrects that mis-impression. For example, New South Wales has acceptance criteria for mercury in biosolids of 20 mg/kg for Grade A (compared to 17 mg/kg for U.S. EQ) and 270 mg/kg for Grade C (compared to U.S. ceiling of 57 mg/kg). France has a limit of 20 mg/kg. The European Union has sludge boundary values for mercury between 16 mg/kg and 25 mg/kg. Most states that regulate biosolids independently have mercury limits between 10 mg/kg and 58 mg/kg.

What may be even more problematic is the allegation of the CWMI that U.S. biosolids are not safe because they do not comply with international regulations. This could not be further from the truth. Table 10 presents a comparison of the concentrations of metals in U.S. biosolids to regulatory limits from around the world.

Table 10
Metal Concentrations in U.S. Biosolids Compared to Standards and Criteria (mg/kg)

Metal	Average Concentration in U.S. Biosolids	EPA EQ limit	European Union	New South Wales (Grade A/C)	Ontario	France
Arsenic	5.8	41		20/20	35/170	
Cadmium	6.7	39	20-40	3/20	4/34	20/40
Chromium	111			100/500	530/2800	1000/2000
Copper	624	1500	1000-1750	150/420	380/1700	1000/2000
Lead	122		750-1200	1/5	220/1100	800/1600
Mercury	3.6	17	16-25	60/270	1.4/11	10/20
Molybdenum	15				1.2/94	
Nickel	50	420	300-400	60/270	80/420	200/400
Selenium	5.7	100		5/50	6/34	100/200
Zinc	1016	2800	2500-4000	200/2500	840/4200	3000/6000

Several conclusions may be drawn from the data in this table. First, it may readily be seen that the U.S. standards are not generally less conservative than standards from other regulatory jurisdictions. For example, the U.S. EQ limit for selenium is equal to or lower than the corresponding regulations. Second, the U.S. regulates chemicals that are not regulated in many other jurisdictions. Arsenic and copper are examples of elements regulated in the U.S. but not regulated elsewhere. Third, the CWMI has included in its tables some metals such as molybdenum and chromium that are not always regulated in biosolids throughout the world. The fourth, and most important conclusion, however, is that actual measurements show that U.S. biosolids are safe when compared to international regulations.

The Cornell document also attempts to make comparisons between concentrations of metals in soils to which biosolids have been applied and regulatory standards for metals in soils (Table 6 and page 10). No calculations or assumptions are shown to support this comparison. CWMI purports to present the calculations of metals in soil after biosolids have been applied as the first stage of this comparison. The source of these data was not given in the document. What is particularly surprising about these values are that they are substantially higher than concentrations of metals in pure biosolids given elsewhere in the Cornell document. For example, Table 7 shows an average for arsenic in New York sludge of 6 mg/kg and U.S. sludge of 10 mg/kg, whereas Table 6 shows an arsenic concentration in soils where biosolids have been applied as 20 mg/kg. Similarly, for cadmium, Table 7 gives the New York State and U.S. average of 7 mg/kg compared to a value of 20 mg/kg on Table 6.

These calculations clearly violate one of the most important scientific principles – that of conservation of mass. Even if pure biosolids were to be applied without any mixing with soil, the soil levels could never exceed those in the pure biosolids.

There are numerous other errors and over-simplifications in CWMI's Table 6. For example, CWMI purports to report EPA soil screening levels for the various chemicals, yet they have biased the presentation by omitting those levels that could be used to portray biosolids in a positive light. For example, the Cornell document presents an "EPA soil screening" level for arsenic of 0.4 mg/kg. EPA (2001c), however, presents soil screening levels (SSLs) for outdoor workers of 2 mg/kg, 4 mg/kg for workers who spend more of their time indoors, and 1-29 mg/kg for groundwater protection. Thus, Cornell purposefully omitted all of the higher criteria for arsenic and presented only the lowest.

Also with respect to Table 6, the Cornell document is also biased with respect to its presentation of background soil values. CWMI presents a row in this table entitled, "Average N. Amer. Agricultural Soils", giving the implication that this value is representative of all of North America. In reality, this value is based on a limited number of soil samples obtained from southern Ontario approximately 30 years ago. As with the regulatory values, these values were selected by CWMI to provide a negative comparison with metal contents in biosolids. A more complete and less biased review of the scientific literature presents an opposite picture to that presented in CWMI's Table 6. Table 11 (below) shows arsenic levels in soils throughout North America gathered from readily available scientific sources compared to the values presented in Table 6 of the Cornell document.

Even if we ignore the violation of conservation of mass in the calculation of the 20 mg/kg, we can still easily see that the CWMI values for arsenic in natural soils are highly biased. Particularly telling is the literature value for Ontario agricultural soils of between 1.1 and 92 mg/kg compared to the value of 6 mg/kg in the Cornell document, which is also ostensibly based on Ontario agricultural soils.

Although a detailed analysis of Cornell's Table 6 is beyond the scope of this peer review, many of the flaws of this table can be seen by a brief analysis including a calculation of metals concentrations in biosolids-amended soils, a review of regulatory levels, and a comparison to background.

Table 12 shows this comparison for metals concentrations in soil that has been treated with biosolids to regulatory levels reported by EPA (2001c) and the Province of Ontario. In addition, we compared these concentrations to ranges of background values reported in the literature.

Table 11
Naturally Occurring Arsenic Levels

Soil Type and Location	Arsenic Concentration (mg/kg)	Source
Typical soil	0.1 – 40	Bodek et al. 1988
Superfund background cleanup levels	3.2 - 21	Davis et al. 2001
U.S. Podzols	<0.1 - 30	Kabata-Pendias & Pendias 1992
Canada Podzols	1.1 - 28.9	Kabata-Pendias & Pendias 1992
U.S. Loam and clay soils	1.7 - 27	Kabata-Pendias & Pendias 1992
Canada Loam and clay soils	1.3 - 16.7	Kabata-Pendias & Pendias 1992
U.S. Chernozems	1.9 - 23	Kabata-Pendias & Pendias 1992
Canada Histosols	1.8 - 66.5	Kabata-Pendias & Pendias 1992
U.S. Histosols	<0.1 - 48	Kabata-Pendias & Pendias 1992
U.S. forest soils	<0.1 - 93	Kabata-Pendias & Pendias 1992
U.S. natural soils	<0.1 - 97	EPA 1999
Ontario agricultural soils	1.1 - 92	EPA 1999
CWMI calculated for "sludged soil"	20	
CWMI average N. Amer. agricultural soils	6	
CWMI 95 percentile N. Amer agricultural soils	10 - 20	

Table 12
Concentrations of Metals in Biosolids-Amended Soils Compared to Regulatory Criteria for Soil and Background Soil Levels (mg/kg)

Metal	Average Soil Concentration (15 cm tilling depth)	Residential SSL	Outdoor worker SSL	Groundwater protection SSLs	Ontario Soil Standards	Background Range
Arsenic	0.21	0.4	2	1-29	14	0.1-40
Cadmium	0.024	70	900	0.4-8	1.6	0.01-2
Chromium	0.21	120,000	1,000,000	NA	120	5-1,500
Copper	2.3	NA	NA	NA	100	0.05-65
Lead	0.44	400	750	NA	60	2-300
Mercury	0.013	23	340	0.1-2	0.5	0.01-0.5
Molybdenum	0.054	NA	NA	NA	4	0.1-40
Nickel	0.18	1,600	23,000	7-130	32	2-750
Selenium	0.02	390	5,700	0.3-5	1.6	0.1-2
Zinc	3.7	23,000	340,000	620-12,000	220	1-900

The results of these comparisons clearly show that metals in biosolids-amended soil meet even the most stringent regulatory criteria and are well below background values. This conclusion is completely contrary to the conclusion presented by the Cornell document on the basis of incomplete and biased data.

5. DISCUSSION AND CONCLUSIONS

There are many aspects of the Cornell document that do not meet generally recognized scientific standards. First, the scientific literature used by the Cornell authors to support their arguments was selectively chosen to eliminate articles that present opposing positions. There is a substantial body of scientific literature that presents positive aspects of biosolids use. An objective scientific report would include both negative and positive findings. Many of the documents cited in this peer review could easily have been incorporated into the Cornell document. This would have resulted in a significant gain in objectivity.

Second, much of the literature used by the Cornell authors to support their position has not been published, not been peer reviewed, and is not even publicly available. For example, the reference list includes other documents created by the same group at Cornell, non-peer reviewed presentations, personal communications, documents published internally at various institutions or not published at all, and documents published by environmentalist advocacy organizations (other than the CWMI). It is highly unusual for a scientific document to rely so heavily on unpublished and un-peer reviewed information. Again, this bias in citations detracts from the objectivity of the document.

Due to a biased selection of literature in conjunction with a misunderstanding of the fundamentals of risk assessment, the Cornell document authors have also made many scientific errors. The combination of scientific errors and disregard for standard scientific principles leads to the conclusion that the Cornell document is fatally flawed. With respect to the twelve issues raised in the Cornell document, we were able to find readily available published information that refuted CWMI's position on each issue.

New scientific evidence is constantly emerging with respect to biosolids and its chemical constituents. It is reasonable to anticipate that scientists, advocacy groups, and regulatory agencies will continue to evaluate new information as it becomes available. Following our examination of the Cornell document, however, we find that there is no evidence that EPA's risk assessment for the 503 Rule did not adhere to generally recognized principles of risk assessment and used all the scientific information available at the time. In addition, our review suggests that the conclusions drawn by EPA from the 503 Rule risk assessment were appropriate and health-protective given the context of the Clean Water Act and the state of risk assessment practice.

6. REFERENCES

Abernathy, C.O. and Dourson, M.L. 1994. Derivation of the inorganic arsenic reference dose. Environ. Geochem. Health 16: 295-304.

Agency for Toxic Substances and Disease Registry (ATSDR). 2000. *Toxicological Profile for Arsenic (Update).* PB2000108021. NTIS, Springfield, VA.

Agency for Toxic Substances Disease Registry (ATSDR). 1999. *Toxicological Profile for Cadmium.* www.atsdr.gov.

Agency for Toxic Substances and Disease Registry (ATSDR). 1989. Public Health Statement for Arsenic. http://www.atsdr.cdc.gov/ToxProfiles/phs88002.html.

Angle, J.S. and Baudler, D.M. 1984. Persistence and degradation of mutagens in sludge-amended soil. J. Environ. Qual. 13(1):143-146.

Berti, W.R. and Jacobs, L.W. 1998. Distribution of trace elements in soil from repeated sewage sludge applications. J. Environ. Qual. 27:1280-1286.

Bodek, I., Lyman, W.J., Reehl, W.F., Rosenblatt, D.H. 1988. *Environmental Inorganic Chemistry.* Pergamon Press, New York.

Bradley, L.J.N., Magee, B.H., Allen, S.L. 1994. Background levels of polycyclic aromatic hydrocarbons (PAH) and selected metals in New England urban soils. Jour. Soil. Contam. 3:349-361.

Chaney, R. 1990. Research provides basis for quantitative risk assessment to make appropriate regulations for land application of sewage sludge: 1) Twenty years of land application research. Biocycle 31(9): 54-59.

Chaney, R.L. and Ryan, J.A. 1994. *Risk Based Standards for Arsenic, Lead and Cadmium in Urban Soils.* DECHEMA, Frankfurt am Maim.

Chang, A.C., Warneke, J.E., Page, A.L. and Lund, L.J. 1984. Accumulation of heavy metals in sewage sludge treated soils. J. Environ. Qual. 13:87-91.

Davis, A .Sherwin, D., Ditmars, R., Hoenke, K. 2001. An analysis of soil arsenic records of decision. Environ. Sci. Technol. 35:2401-2407.

Davis, R.D., Howell, K., Oake, R.J., and Wilcox, P. 1984. Significance of organic contaminants in sewage sludges used on agricultural land. International Conference on Environmental Contamination, Imperial College, London, July 10-13. pp 73-79.

Dorn, C.R., Redy, C.S., Lamphere, D.N., Gaeuman, J.V., and Lanese, R. 1985. Municipal sewage sludge application on Ohio farms: Health effects. Environ. Res. 38:332-359.

Draeger, K.J., Pundsack, M.D., Jorgensen, M.D., and Mulloy, P.J. 1999. *Watershed Effects of Biosolids Land Application – Literature Review.* WERF Project 96-REM-2, WERF, Alexandria, VA.

Drescher-Kaden, U., Bruggeman, R., Matthes, B. and Matthies, M. 1992. Contents of organic pollutants in German sewage sludge. In *Effects of Organic Contaminants in Sewage Sludge on Soil Fertility, Animals, and Plants.* J.E. Hall et al. Eds. Commission of the European Communities, Luxembourg.

Environmental Protection Agency (EPA). 2001a. Integrated Risk Information System (IRIS). http://www.epa.gov/iris.

Environmental Protection Agency (EPA). 2001b. Region III Risk-Based Concentrations. http://www.epa.gov/reg3hwmd/risk/riskmenu.htm.

Environmental Protection Agency (EPA). 2001c. *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites.* Peer Review Draft. OSWER 9355.4-24. March 2001.

Environmental Protection Agency (EPA). 1999. *Control of Pathogens and Vector Attraction in Sewage Sludge.* EPA/625/R-92/013.

Environmental Protection Agency (EPA). 1998. *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities.* Peer Review Draft. Solid Waste and Emergency Response. EPA 530-D-98-001A. July 1998.

Environmental Protection Agency (EPA). 1997. *Exposure Factors Handbook.* EPA/600/P-95/002Fa.

Environmental Protection Agency (EPA). 1995a. *A Guide to the Biosolids Risk Assessments for the EPA Part 503 Rule.* EPA 832-B-93-005.

Environmental Protection Agency (EPA). 1995b. *Land Application of Sewage Sludge and Domestic Septage.* EPA/625/R-95/001

Environmental Protection Agency (EPA). 1995c. *Pathogen Risk Assessment Methodology for Municipal Sewage Sludge Landfilling and Surface Disposal.* EPA/600/R-95/016.

Environmental Protection Agency (EPA). 1992. *Technical Support Document for Part 503 Pathogen and Vector Attraction Reduction Requirements in Sewage Sludge.* PB93-11069. NTIS, Springfield, VA.

Environmental Protection Agency (EPA). 1991. *Preliminary Risk Assessment for Viruses in Municipal Sewage Sludge Applied to Land.* EPA/600/SR-92/064.

Environmental Protection Agency (EPA). 1989a. *Risk Assessment Guidance for Superfund.* Volume I. EPA/540/1-89/002.

Environmental Protection Agency (EPA). 1989b. *Technical Support Document For Pathogen Reduction in Sewage Sludge.* PB89-136618. NTIS, Springfield VA.

Environmental Protection Agency (EPA). 1986. *Inactivation of Enteric Pathogens During Aerobic Digestion of Wastewater Sludge.* EPA/600/SO-86/047.

Fresquez, P.R., Francis, R.E., and Dennis, G.L. 1990. Sewage sludge effects on soil and plant quality in a degraded semiarid grassland. J. Environ. Qual. 19:324-329.

Girovich, M.J. 1996. *Biosolids Treatment and Management.* Marcel Dekker, New York.

Haas, C.N., Anotai, J., Engelbrech, R.S. 1996. Monte Carlo assessment of microbial risk associated with landfilling of fecal material. Water Environ. Res. 68:1123-1131.

Hrudey, S.E., Chen, W., Rousseaux, C.G. 1996. *Bioavailability in Environmental Risk Assessment.* Lewis-CRC.

Jacobs, L.W., O'Connor, M.A., Overcash, M.A. et al. 1987. Effects of trace organics in sewage sludges on soil-plant systems and assessing their risk to humans. In *Land Application of Sludge: Food Chain Implications.* A.L. Page et al. eds. Lewis Publishers, Chelsea, MI.

Jones, K.C. and Wild, S.R. 1991. *Organic Chemicals Entering Agricultural Soils in Sewage Sludges: Screening for Their Potential to Transfer to Crop Plants and Livestock.* Report No. FR0169. FWR, Marlow, Bucks.

Kabata-Pendias, A. and Pendias, H. 1992. *Trace Elements in Soils and Plants,* 2nd Ed. CRC Press.

Lester, J.N. 1983. Occurrence, behaviour and fate of organic micropollutants during waste water and sludge treatment processes. In Environmental Effects of Organic and Inorganic Contaminants in Sewage Sludge. R.D. Davis et al. eds. Reidel Publishing, Dordrecht.

Lue-Hing, C., Pietz, R.I., Tata, P., Johnson, R., Sustich, R., Granato, T.C. 1999. A national sewage sludge survey: Quality status relative to the Part 503 Rule. WEFTEC 99, New Orleans, LA.

Mortvedt, J.J. 1996. Heavy metal contaminants in inorganic and organic fertilizers. Fertilizer Res. 43:55-61.

National Academy of Science/National Research Council (NAS/NRC). 2001. *Arsenic in Drinking Water 2001 Update*. NAS Press. Washington DC.

National Academy of Sciences (NAS). 1994. *Science and Judgment in Risk Assessment*. NAS Press, Washington, DC.

National Academy of Sciences (NAS). 1983. *Risk Assessment in the Federal Government: Managing the Process*. NAS Press, Washington, DC.

New York Department of Environmental Conservation (NYDEC). 1997. *A Technical Review of: "The Case for Caution" Recommendations for Land Application of Sewage Sludges and an Appraisal of the USEPA's Part 503 Regulations"*. NYDEC. Division of Solid & Hazardous Materials. Albany, NY. November.

Oak Ridge National Laboratories (ORNL). 1997. *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants*. ES/ER/TM-85/R3. *Toxicological Benchmarks for Contaminants o Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process*. ES/ER/TM-126/R2.

Presidential/Congressional Commission on Risk Assessment and Risk Management. 1996. *Framework for Environmental Health Risk Management*. www.riskworld.com.

Pillai, S.D., Widmer, K.W., Dowd, S.E., Ricke, S.C. 1996. Occurrence of airborne bacteria and pathogen indicators during land application of sewage sludge. Appl. Environ. Microbiol. 62(1): 296-299.

Rhomberg, L.R. 1996. A survey of methods for chemical health risk assessment among federal regulatory agencies. Presidential/Congressional Commission on Risk Assessment and Risk Management. www.riskworld.com.

Ryan, J. and Chaney, R. 1993. Regulation of municipal sewage sludge under the Clean Water Act Section 503: A model for exposure and risk assessments for MSW compost. In *Science and Engineering of Composting*. Renaissance Publications, Worthington, OH.

Roberts, S. 2001. Presentation to Florida Department of Environmental Protection. University of Florida.

Sadowitz, M. and Graham, J.D. 1995. A survey of permitted residual cancer risks. Risk: Health, Safety & Environment. 6:17-35.

Samaras and C.D. Tsadilas (sic). 1999. Recycling of municipal wastes in agriculture. I. Sewage Sludge Applied to Corn Crop. www.environmental-expert.com/events/r2000/r2000.htm.

Smith, S.R. 1991. *Agricultural Recycling of Sewage Sludge and the Environment.* CAB International, Wallingford, UK.

Smith, J.E. and Farrell, J.B. 1996. Current and future disinfection – Federal perspectives. WEF 69th Annual Conference & Exposition. Charlotte, NC.

Stanek, E.J., Calabrese, E.J., and Zorn, M. 2001. Soil ingestion distributions for Monte Carlo risk assessment in children. Human Ecol. Risk. Assess. 7:357-368.

Sterrett, S.B., Chaney, R.L., Giffird, C.H., Mielke, H.W. 1996. Influence of fertilizer and sewage sludge compost on yield and heavy metal accumulation by lettuce grown in urban soils. Environ. Geochem. Health 18:135-142.

Straub, T.M., Pepper, I.L., and Gerba, C.P. 1993. Hazards from pathogenic microorganisms on land-disposed sewage sludge. Rev. Eviron. Contam. Toxicol. 132:55-91.

Sweetman, A.J. 1991. Review of Dioxins in Sludge and their Significance to Sludge Utilisation in Agriculture. WRc Report No. UM 1199. WRc Medmenham, Marlow, Bucks.

Verschueren, K. 2001. *Handbook of Environmental Data on Organic Chemicals.* Fourth Ed. Wiley-Interscience.

Water Environment Federation (WEF). 2001. Biosolids Success Stories. WEF, Alexandria VA.

Webber, M.D. and Nichols, J. 1995. Organic and metal contaminants in Canadian municipal sludges and sludge compost. Wastewater Technology Centre, February 1995, Burlington.

COMPOST OPERATORS FORUM

A high pressure wash water truck is used inside the composting building in Longmont, Colorado to reduce dust.

Controlling Dust And Bioaerosols At A Biosolids Composting Facility

Studies at enclosed Longmont, Colorado project evaluate exposure level of employees. Operational changes reduce dust, endotoxin and *A. Fumigatus* by 90 percent.

Eliot Epstein, Nerissa Wu, Calvin Youngberg and Gerald Croteau

WHEN dealing with public health issues and composting, attention has been predominantly focused on potential exposure from the release of *Aspergillus fumigatus* (*A. fumigatus*) from composting facilities. Numerous studies were conducted to assess the level of *A. fumigatus* spores concentration in the areas surrounding composting facilities and to compare this to the levels of *A. fumigatus* found in remote areas (areas unrelated to composting facilities).

Two early studies — in 1984 and 1987 — focused on worker exposure, but neither study showed any significant worker health problems. Recently, the increase in composting activities, particularly when composting involves the handling of yard trimmings, and the trend towards controlling odors by enclosing facilities, have revived concern for worker exposure to *A. fumigatus* and other bioaerosols. Although there are no reported cases in the literature of occupational impacts at biosolids composting facilities in the United States, E&A Environmental Consultants, Inc. (E&A) has encountered two cases of employees developing symptoms related to dust. One individual — an employee at a biosolids/municipal solid waste facility (and, incidentally, a heavy smoker) — reported respiratory discomfort at the end of the work week that would improve over the weekend. Symptoms disappeared during his vacations. A second employee at a biosolids/wood chip composting facility developed a rash on the face and scalp.

The study reported here was designed for the city of Longmont, Colorado, which wanted to evaluate the level of exposure of employees to

Table 1. Total and respirable dust

Composting Activity	Winter 1996 (mg/m³) Total Dust	Winter 1996 (mg/m³) Respirable Dust	Summer 1997 (mg/m³) Total Dust	Summer 1997 (mg/m³) Respirable Dust
eedstock mixing	<0.50	<0.25	0.68	<0.18
	1.09	<0.37	0.50	<0.18
	1.12	<0.25	11.81	1,221.27
Pile construction	1.09	<0.37	9.16	
	5.66	1.26	44.51	0.90
	4.11	0.94	29.80	1.47
Pile break-down	7.06		26.29	
	3.41	0.75	128.64	0.63
	3.12	0.54	77.21	<0.23
Pile screening	2.55		247.21	
	<0.35	<0.24	<0.38	<0.3
Compost building (no activity)	<0.35	<0.24	<0.39	<0.3

dust, endotoxin, and *A. fumigatus*, and to determine if operational and design changes to the facility could reduce the airborne concentration of these constituents. Longmont has operated a 7.7 dry metric tons/day aerated static pile biosolids composting facility since 1991. The facility consists of a totally enclosed mixing building and a separate, totally enclosed composting/curing and screening building. Dust is a major problem in the facility due to the extremely dry climatic conditions (see sidebar).

In this paper, E&A presents data on dust, endotoxin, and *A. fumigatus* concentrations as related to various activities within the composting facility. Based on these results, operational mitigation measures were recommended, and the impacts of those modifications are reported.

Sampling Air Quality Inside Facilities

Two air sampling events were conducted to determine facility conditions in winter and summer climates. Air quality parameters included total dust, respirable dust, endotoxin, and *A. fumigatus*. In addition, eight-stage Marple Multiple Cascade Impactors — which collect particulates in separate size ranges between 0.52 and 21.30 μ — were worn by employees for the entire work shift during the winter monitoring period. Ambient temperatures during the winter ranged from -18°C to -7°C; summer temperatures ranged from 13°C to 18°C. All air samples were taken at a height of 1.5 meters. Airflows were calibrated daily using a bubble calibrator.

Air monitoring was conducted during the following activities: feedstock mixing, pile construction, pile covering (winter monitoring only), pile teardown, and screening. Sampling was also conducted during a period with no activity.

Total airborne dust was determined using NIOSH Method 0500, and respirable dust concentrations were determined by collecting samplings through a nylon cyclone and using NIOSH Method 0600 (NIOSH is the National Institute of Occupational Safety and Health.) Airborne endotoxin concentrations were determined using the Limulus amebocyte lysate test on samples collected

using NIOSH Method 0500. Samples for *A. fumigatus* evaluation were collected using an Andersen Two-Stage Impactor, according to ASTM Method E 884-82. Samples were collected on oxgall-gentamicin petri plates at a rate of 28.3 liters per minute.

Dust and Endotoxin

Table 1 shows the total and respirable dust concentrations measured during sampling periods in the winter of 1996 and the summer of 1997 as related to the various composting activities in the enclosed facility. The winter sampling event found very low dust levels that never exceeded OSHA PEL standards (Occupational Safety and Health Agency — particulate emission limit) of 15 mg/m^3 for total dust and 5 mg/m^3 for respirable dust. Much higher total dust concentrations were found during the summer sampling period. During pile breakdown, which is performed with a front-end loader, and during screening, high total dust levels during the single time measurements did exceed the OSHA PEL standards.

Figure 1. Effect of dust control on total and respirable dust

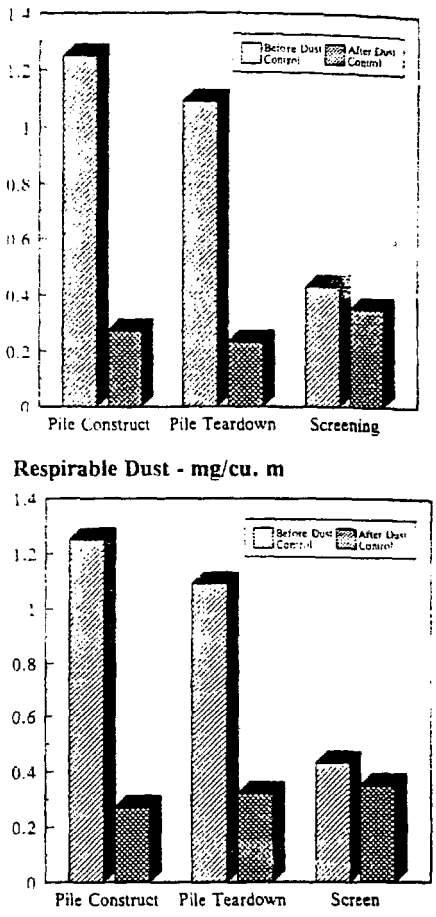


Table 2 shows the data obtained using the Marple Multiple Cascade Impactor personal dust samplers. Two employees wore the samplers; one employee (Operator #2) participated on two different days so that data from three different workdays were obtained. Operator #1 conducted most of his activities from the cab of an enclosed front-end loader. Operator #2 spent his time both in the loader, cab and on the open floor where most of the activities take place. On Day 1, Operator #2 was in the mixing building where biosolids and sawdust were being mixed. This activity required Operator #2 to frequently exit the loader cab and monitor the mixing operations from ground level. On the second day, Operator #2 was involved in pile teardown and screening using a loader.

As shown in Table 2, the operators in the mixing area are exposed to a greater overall dust concentration than operators involved in the other two activities. The percent of dust that is respirable is lower in the mixing area than in the other two areas; however, exposure to respirable

Controlling Dust And *A. Fumigatus* Emissions

THE CITY of Longmont, Colorado began operating its aerated static pile biosolids composting facility in May, 1991. Capacity is eight dry tons/day, but the site processes about 2.5 dry tons/day of biosolids (annual average), with the remainder being anaerobically digested and land applied. In the original design, the mixing building was completely enclosed and the composting/curing building was enclosed only on two sides. That rendered the odor control method for the process air – dispersion and dilution – ineffective, as the wind blowing through the open sides overwhelmed the upblast fans, transporting odors off-site.

In early 1992, walls were added to the composting/curing building. "In addition to allowing us to more effectively control and disperse the air from the piles, the enclosure helped prevent nuisance conditions, such as blowing materials and fugitive dust, and freezing of the piles," says Cal Youngberg of the city of Longmont.

Because of the semiarid climate, dust had been an issue to address early on in the facility's operation. "From the start, air filters were specified for all loader cabs," notes Youngberg. "The staff also wore respirators when working in dusty areas. However, we felt that more efforts were needed to make the site safer, which led us to initiate the study in 1996 with E&A to determine the level of employee exposure to dust, endotoxin and *A. fumigatus* and to see what operational or design changes could be made to reduce concentrations in the air. And as a side benefit, dust control also reduces any possibilities of fugitive dust problems."

The accompanying article describes the results of the air sampling and briefly describes the steps taken to control dust in the buildings. The report issued in January, 1997 by E&A Environmental Consultants suggested that Longmont purchase a high pressure wash water truck and use it in the composting building and high traffic areas and to install a dust collection system over the screen that operates in the composting building. These recommendations were implemented in the spring of 1998. At this time, the wash water truck primarily is used to keep dust off the equipment traffic areas. "The traffic routes are washed down about once a week," says Grant Grover, Longmont's composting facility supervisor. "During warmer months, the composting piles have been sprayed with water before breakdown to reduce dust from this operation."

With the dust collection system, the hopper, screen deck and overs and unders discharge conveyors were enclosed with galvanized steel collection hoods. Explains Eliot Epstein, president of E&A: "Plastic curtains allow the loading of the screen. Air is evacuated from the hoods by an 11,800 cfm fan. The dust laden air is passed through a Torit Downflo continuous duty, reverse pulse, cartridge style dust collector, which has 6,096 sq.ft. of filter material rated at 99.999 percent efficiency for 0.5 micron diameter sized particles." The estimated cost for the dust control system was about $200,000.

Figures 1 and 2 in the accompanying article provide the results of measurements taken after the dust control system was installed and mitigation measures were implemented. Operational controls involve the timing of activities (such as pile breakdown), maintenance of initial core moisture content at 40 percent and tight aeration control. "Aeration rates are usually not changed during the 28 day active composting period," says Grover. "After this period, aeration is reduced until the product is screened. Fogger nozzles installed on the conveyor help with moisture control and are very effective for fugitive dust control, as is the water truck." He adds that the dust collection system is effective if cross currents – wind from the open doors in the building – are controlled and moisture is not sucked into the canister filters. "Moisture will blind the filters and reduce their efficiency," he notes. "Overall, moisture has not really been a problem for us."

Maintenance on the dust control system has been minimal, says Grover. "We have replaced the cartridge filters once since we started using the system – parts cost about $2,400 – and the system fans only have needed regular lubrications, which is a minor task. Overall, the cost and time involved in running the system are probably less than the screen." — N.G.

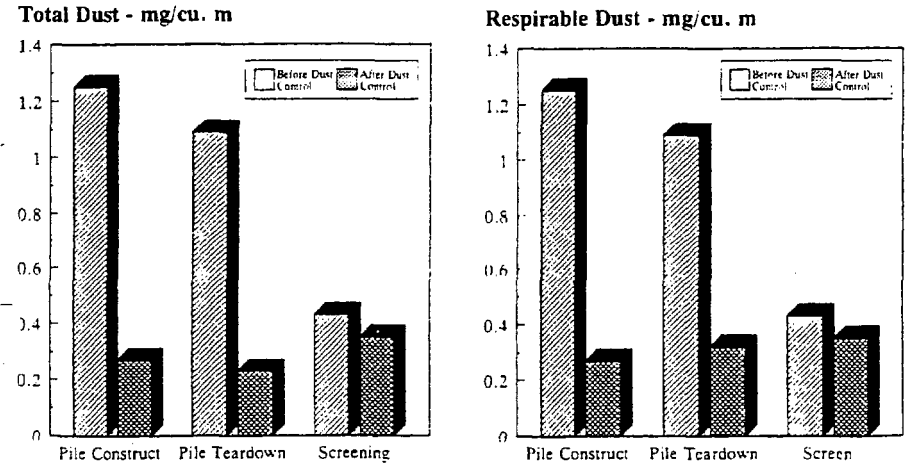
COMPO OPERA FORUM

dust appears to be higher in the mixing area.

Table 3 shows the endotoxin and *A. fumigatus* concentrations. There are no regulatory standards for endotoxin although some thresholds have been proposed. The International Committee on Occupational Health (ICOH) has proposed the following threshold levels: 20 to 50 ng/m³ = mucous membrane irritation; 100 to 200 ng/m³ = acute bronchial constriction; 100 to 2,000 ng/m³ = organic dust toxic syndrome (ODTS). The Dutch Expert Committee on Occupational Standards of the National Health Council proposed a health-based recommended limit value of 4.5 ng/m³ over an eight-hour exposure period.

In most cases, the endotoxin levels were sufficiently high to elicit respiratory response. None of the results suggest that workers may be susceptible to ODTS. Employees at the facility predominantly work in enclosed cabs of loaders, which have filters. Furthermore, the employees spend relatively few hours at any one location within the three buildings on the site. During part of the day, they are in areas in which dust and bioaerosol levels are considerably lower. Therefore, over an eight-hour working period, the average exposure may be lower than the reported values.

Figure 2. Effect of dust control on Endotoxin and *Aspergillus fumigatus*



Aspergillus fumigatus

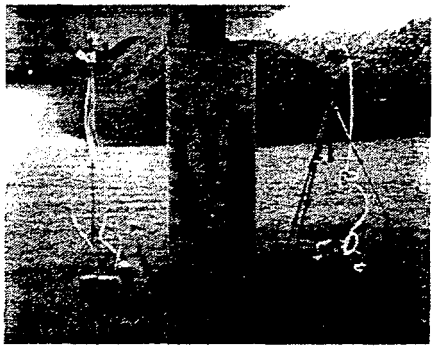
The winter data for *A. fumigatus* were questionable since the air temperature at the time of sampling was very low, and it is possible that the spores did not adhere to the agar in the plates. The summer data indicated that *A. fumigatus* was greatest during feedstock mixing. Low levels of *A. fumigatus* were found during the screening operation, in contrast to other reported studies. It is possible that the extremely dry conditions reduced the viability of existing spores: the Anderson sampler methodology only determines the concentration of viable spores. Although the nonviable spores do not represent a pathological health hazard (i.e., Aspergillosis), they can elicit an allergic response in humans. Future sampling should include methods of *A. fumigatus* determination that measure both viable and nonviable spores.

Recommendations For Dust Mitigation And Reducing Worker Exposure

As a result of these data, E&A recommended several dust mitigation measures. The primary recommendations included: Increase moisture content of the feed mix: Adjust air flow to reduce drying prior to screening; Suppress dust on the composting area floor using a water truck; Place a dust hood and a baghouse dust collection system over the screen; and Place a water misting system over screen conveyors.

Table 2. Personal dust sampling results (Marple Multiple Cascade Impactor)

		Operator #1 Day 1 - Composting		Operator #2 Day 1 - Mixing		Operator #2 Day 2 - Composting	
Rate (l/min)		2.00		2.00		2.00	
Elapse Time (min)		350		355		228	
Volume (m^3)		0.70		0.71		0.46	
Stage	Size Range (µm)	Weight (mg)	Concentration (mg/m^3)	Weight (mg)	Concentration (mg/m^3)	Weight (mg)	Concentration (mg/m^3)
1	>21.3	0.04	0.06	0.16	0.23	<0.01	<0.02
2	15.0 - 21.3	<0.01	<0.01	0.24	0.34	<0.01	<0.02
3	10.0 - 15.0	0.03	0.04	0.32	0.45	<0.01	<0.02
4	6.0 - 10.0	0.04	0.06	0.10	0.14	<0.01	<0.02
5	3.5 - 6.0	<0.01	<0.01	0.08	0.11	0.01	0.02
6	2.0 - 3.5	0.01	0.01	0.06	0.08	0.06	0.13
7	1.0 - 2.0	0.05	0.07	<0.01	<0.01	0.01	0.02
8	0.6 - 1.0	0.01	0.01	0.01	0.01	<0.01	<0.02
	<0.6	0.22	0.31	0.03	0.04	0.04	0.09
Total		0.40	0.57	1.00	1.41	0.12	0.26
% Nonrespirable		>15		>71		<1	
% Respirable		<85		<29		>99	



Air sampling is conducted during feedstock mixing, pile construction/ covering/teardown, and screening.

The first four recommendations have been implemented. Significant reductions (90 percent) in total dust, respirable dust, endotoxin, and *A. fumigatus* were found in the composting hall following the implementation of the mitigation measures (see Figures 1 and 2).

Primary recommendations included more moisture in the feed mix, adjust air flow to reduce drying prior to screening, and suppressing dust on the floor by using a water truck.

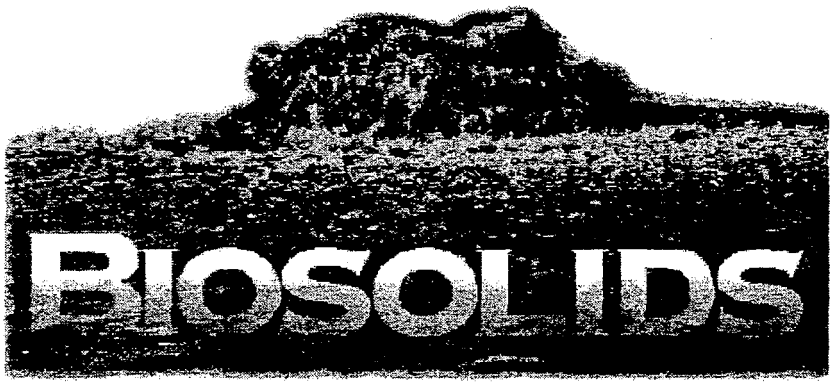
Workers at enclosed biosolids composting sites may be subject to frequent exposure to high levels of dust, endotoxin, and *A. fumigatus* for short periods of time. There are several very effective design and operational measures that can reduce worker exposure. These include: Moisture control of feedstock and composting; Isolation of the screening operation from the composting operations; Dust control and collection systems in dry climates; Sweepers and water vehicles to control dust in roadways; Air filters in loaders and other mobile equipment; Adequate ventilation in buildings; and Personal hygiene equipment. ■

Table 3. Endotoxin and *A. fumigatus*

Composting Activity	Endotoxin (ng/m^3) Winter 1996	Summer 1997	*A. fumigatus* (CFU/m^3) Winter 1996	Summer 1997
Feedstock mixing			159	
			876	>1,587
	77	16	141	1,151
	12	<0.5	14	6,241
Pile construction				231
	38	<0.5	0	769
	186	251	0	<385
Pile breakdown				<74
	22	284	0	<222
	176	>640	21	<444
Pile screening				<148
				<74
	168	>260	0	<317
	305	>488	0	<444
Compost building (no activity)				2
	229		12	<3
	211	<0.70	0	<7

Eliot Epstein is with E&A Environmental Consultants in Canton, Massachusetts. Nerissa Wu was with E&A when this work was done. Calvin Youngberg is with the City of Longmont, Colorado. Gerald Croteau is in the Bothell, Washington office of E&A.

The Beauty of



Whether dumped from trailers, sprayed by manure spreaders, emptied out of bags, or injected into the soil by specialized vehicles, millions of tons of an organic material rich in plant nutrients are being added to U.S. soil each year. The material is biosolids, an inevitable by-product of the sewage treatment plants that serve about 75% of the U.S. population.

But because biosolids contain concentrations of most heavy metals as well as some pathogens and toxic organics that are flushed and dumped down residential and industrial drains, the question arises of whether biosolids are safe to be spread on farms and forests. Despite the common misconception that biosolids and sewage are identical, well-treated biosolids resemble sewage about as much as a plastic bag resembles the crude oil from which it originated. Biosolids are made through a series of biological transformations in which most of the complex organic molecules in sewage are decomposed and most of the pathogens killed. Nevertheless, aware that the label "sewage sludge" is enough to arouse public fear and opposition, advocates of sludge recycling coined the term "biosolids" a few years ago. In a 9 December 1996 memo to the EPA's Office of Water employees, EPA Assistant Administrator Robert Perciasepe encourages them to use the term "biosolids" in place of "the 's' words ('sludge' and 'sewage sludge')." In the memo Perciasepe calls the use of the term biosolids "an important component in accomplishing one of EPA's policy objectives--supporting and encouraging the beneficial use of these residuals of wastewater treatment."

Still, whatever it's called, the idea of using the residues of sewerage treatment plants in agriculture is sure to arouse opposition--or at least concern over the impacts on health and the environment.

How Much Sludge

In the process of treating 182 gallons of sewage per person per day, treatment plants create 7 million dry metric tons of biosolids, mixed in roughly 700 million tons of water, according to the EPA. This number dwarfs total municipal solid waste production, which is 210 million tons annually.

Therefore, sewage treatment plants face a monumental problem of how to dispose of or reuse biosolids. According to a 1993 EPA report, Standards for the Use or Disposal of Sewage Sludge, about 2.5 million dry tons of biosolids, or 36% of the total amount, was being recycled on farms, forests, golf courses, and elsewhere in the late 1980s, compared to 24% of municipal solid waste now being recycled. The balance of biosolids was buried in landfills (38%), burned (16%), or surface

disposed by other means (10%).

Until 1992, millions of tons of biosolids ended up in the Atlantic Ocean. The practice was banned due to public concern over ocean pollution; the banning led to the expanded need for land disposal, which now accounts for 40-50% of biosolids disposal, according to Alan Rubin, a scientist in the Office of Water. Because biosolids are created whenever sewage is treated, the environmental health effects of land application should be evaluated in comparison to other disposal techniques. Because landfilling and incineration each have health and environmental drawbacks and offer none of the potential benefits of recycling, EPA policies express a preference for land application.

Where It Comes From

Biosolids are no more optional to an urbanized society than sewage treatment itself, since they are an inevitable byproduct of treatment. The first treatment works were crude by today's standards, but spurred by public demands for a cleaner environment, treatment has continually improved. When sewage enters a treatment plant, it runs through a series of tanks where heavy material--the biosolids-to-be--settles to the bottom, and water is skimmed off the top.

To minimize environmental damage to a lake or river in which the water is disposed, the effluent is treated to reduce the levels of nitrogen and/or phosphorus, and is often disinfected with ultraviolet light or chlorine. Nationally, 3% of sewage plant wastewater is used for agricultural irrigation, mostly in the Southwest. Although the practice raises health concerns that parallel those of biosolids recycling, a National Research Council (NRC) committee that studied the issue and wrote a report, Use of Reclaimed Water and Sludge in Food Production, found few signs that wastewater was causing disease or pollution.

In the treatment plant, anaerobic or aerobic bacteria metabolize the solids in wastewater and settle to the bottom. When these bacteria have finished, wastewater contains about 1% solids, largely organic material from the decomposing bacteria. In dry-weight composition, biosolids resemble animal manure, typically containing 3% nitrogen (manure contains 1.7-7.8%) and 1.5% phosphorus (manure contains 0.3-2.3%). Both materials also contain sulfur, calcium, magnesium, potassium, and other elements, according to the NRC.

When applied to land, the organic matter in biosolids improves the soil's structure, increases its water-holding capacity, and feeds essential soil microorganisms. It's not just organic farmers who worry about the decline in organic matter in farm fields. Robert Brobst, biosolids program coordinator for the EPA's Region 8, notes that on the eastern plains of Colorado, half of the organic matter has disappeared since farming began. Brobst calls biosolids a good source of organic matter that can be used to build up the soil by feeding naturally occurring bacteria. "With chemical fertilizers, you are feeding the plant directly. With sludge, you feed the soil and the soil feeds the plants," says Brobst. "It will take a long time, but at least we are going in the right direction" by increasing the soil's organic content.

Where It Goes

Sewage plants have always had to dispose of biosolids; ironically, better treatment removes more solids and thus creates more biosolids. One of the first recycling efforts began in 1926, when Milwaukee began selling dried biosolids to homeowners and landscapers as fertilizer. According to the EPA, about 12% of all recycled biosolids are given or sold to the public in containers.

Approximately 9% of recycled biosolids are used to revitalize land that's been damaged, usually by mining. For many years, Chicago's biosolids were spread on former coal strip mines in Fulton County, Illinois, 190 miles southwest of Chicago. About 2,000 acres of damaged land owned by the Metropolitan Sanitary District of Greater Chicago has been returned to agriculture and is leased to farmers, says district soil scientist Scott Nelson. Here and elsewhere, sludge has also been used to

rejuvenate spoils heaps--multi-acre piles of acidic rock where nothing had grown decades after mining had stopped. An enormous amount of biosolids--up to 1,000 dry tons per acre--increased the organic content of the heaps, and 70 tons of lime per acre neutralized the acidity. Today the land is prairie, and the runoff of acid mine drainage, which commonly carries toxic chemicals from abandoned strip mines, has practically ceased.

In Washington State, Seattle's biosolids are sprayed into forests, a practice that nationwide accounts for about 3% of total biosolids recycling. In forests, terrain is a key restriction to biosolids use. If the land slopes more than 10-20%, the biosolids may quickly wash into watercourses.

Fully 67% of recycled biosolids go to farmland, where they are spread on, or injected under, soil. In Wisconsin, where the Madison Metropolitan Sewerage District's "Metrogro" program is often held up as a national model, fields are chosen based on soil type, depth to groundwater and bedrock, and slope. "If there's high permeability, or potential for runoff, we're not allowed to go on them," says David Taylor, a district soil scientist who directed the Metrogro program for many years. Since excess nitrogen pollutes groundwater and surface water, the district applies the amount of biosolids that will supply only enough nitrogen for the next crop. The farmer's $7.50 per acre payment covers application with the district's trucks, tests of the soil, plant tissue, and well water, and all required recordkeeping. Although the fee only funds 1-2% of the biosolids program, Taylor says it helps present biosolids "as a resource, not a waste."

Farmers in the surrounding area seem to approve, and have offered about seven times as much land as the district needs for its annual application of 3,000-4,000 acres per year. The high level of acceptance can be credited to clean biosolids, a 20-year history of monitoring pollutant levels in biosolids, soil, water, and plant tissue, and the district's support for university research on cheaper and cleaner sewage treatment. Importantly, the district has also shouldered the extra expense of injecting sludge into the soil, preventing odor and sight problems that enrage neighbors of some land application projects.

Public Health and the EPA Regulations

Despite the noted benefits of using recycled biosolids, many still question whether the heavy metals, toxic organic compounds, and pathogens in this material could contaminate soil, water, or food and ultimately cause health problems. This doesn't appear likely. A search of the National Library of Medicine's comprehensive Medline database revealed no scientific article claiming that sewage sludge had caused disease. Conceivably, that negative result could result from inadequate research, but given the long history of concern, "if it was causing a problem, it would make itself apparent, and it hasn't," says Sarah Clark Stuart, a member of the NRC committee and a program officer at the Pew Charitable Trusts in Philadelphia, Pennsylvania.

Nationally, biosolids recycling is governed by a regulation of the Clean Water Act known as "Part 503" regulation, issued in 1993 by the Office of Water. The goal of the rule is to maintain or improve environmental quality and protect human health. EPA policies encourage biosolids recycling. Rubin, who says he "wrote the [EPA] regulations" on biosolids recycling, is categorical: "We have yet to receive one documented negative human health case where a biosolids program met all the federal and state requirements, and was used the way it should be used--according to good agricultural practices." Nevertheless, NRC committee member Michael Baram, a professor at Boston University Law School, says he found some sludge applicator workers who blamed their hepatitis B infections on biosolids. Baram believes that indicates that the EPA should have worked with the Occupational Safety and Health Administration and the Food and Drug Administration while writing the biosolids rules.

Pathogens. The most characteristic potential health hazard of biosolids are the wide range of pathogenic microbes carried in sewage. The list includes Salmonella and Shigella bacteria, the hepatitis A and Coxsackie viruses, the Giardia and Cryptosporidium protozoans, and helminths

(parasitic worms) that cause roundworm, tapeworm, and hookworm. Based on microbial content, Part 503 established two categories of biosolids. To achieve Class A status, with pathogens below detectable levels, a treatment plant can either test directly for pathogens or use one of five specific treatments to kill them, including heating or increasing biosolids alkalinity. Class A biosolids can be applied in the same way as commercial fertilizer, without the restrictions that govern Class B sludge.

The process for making Class B sludge, which is produced by most large treatment plants, must be known to reduce indicator microorganisms (including some pathogens) below 2 million colony forming units of fecal coliform per gram of dry weight. (Fecal coliform, common, nonpathogenic bacteria that originate in the human gut, are considered "indicator organisms" for how effectively the treatment has killed all pathogens.) For Class B, the approved treatments include aerobic or anaerobic digestion, composting, heat treatment, and drying. Treatment can drastically reduce bacterial counts. According to the EPA, raw sewage typically contains about 1 billion fecal coliform bacteria per 100 ml of sewage; treated biosolids range from 30,000 to 6 million per 100 ml. Similarly, 100 ml of raw sewage contains an average of 8,000 Salmonella bacteria, while treated biosolids range from 3 to 62.

Indicators are used because it's expensive to identify and count microbes in biosolids. But Suresh Pillai, an assistant professor of environmental microbiology at Texas A&M University who has studied pathogens at the 128,000-acre New York City biosolids disposal site in west Texas, says counting fecal coliform can be "misleading and unreliable; it underestimates the actual presence of organisms." Pillai calls the bacterial genus Clostridium "a much better indicator of [bacterial] survival and transmission in anaerobically digested sludge."

A key concern with Class B sludge is the eggs of parasitic worms called helminths, which survive sewage treatment and soil processes better than most pathogens. To prevent transmission of helminths and other resistant organisms, farmers must wait before harvesting crops on land that has received Class B sludge. This allows time for many of the organisms to die in the soil.

Pathogens worried the NRC study group, which suggested the "EPA should continue to develop and evaluate effective ways to monitor for specific pathogens in sewage sludge." The NRC panel said that since the part 503 regulations rely so heavily on processes rather than pathogen tests, "reliability must be a critical element in the design and operation of wastewater treatment plants."

Organics. Toxic chemicals that do not volatilize or decompose during treatment tend to concentrate in biosolids, and yet their residues have declined greatly over the past 20 years. For example, benzene was detected in 93% of biosolids samples in a survey during the late 1970s, but in only 3% of samples from the late 1980s. Likewise, detections of organochlorine pesticides (which are no longer on the market) have also declined: chlordane, dieldrin, heptachlor, and hexachlorobenzene were each detected in 16% of the 1970s samples, but in none of the 1980s samples.

To develop the Part 503 regulations, the EPA screened about 200 toxic organic compounds. After performing detailed risk analyses on the 22 that seemed most threatening, the agency decided that they appeared so rarely, or at such low concentrations, that they did not need regulation in Part 503. "We concluded that the numerical limit we would promulgate would be at least an order of magnitude greater than the highest level of that pollutant that was found in biosolids," Rubin says.

The NRC committee questioned this decision, arguing that the EPA's own methodology indicated that the "concentration [of certain toxic organics] in sewage sludge may exceed the risk-based limits." Because the data showing that toxic organics would not pose a hazard came from the National Sewage Sludge Survey of the late 1980s, about which some methodological concerns had been raised, the NRC committee urged the EPA to repeat the survey. "I felt the issue should be looked at with a new survey," says Stuart. "Not that I thought that toxic organics were necessarily a health or environmental problem," she said, but to instill confidence in land application, "[I felt the] EPA should try to cover its bases better."

Rubin counters that monitoring systems already in place, including the annual "priority pollutant scan" (for up to 127 compounds) required by some states for biosolids at large treatment works, show "that if anything, biosolids quality is improving." A repeat survey, he says, would "waste the taxpayers' money." Nevertheless, some changes in the rules governing toxics in biosolids are in the works. According to Rubin, a second round of part 503 regulations, scheduled for proposal in 1999, will cover dioxins, dibenzofurans, and the so-called "co-planar" PCBs, which are considered the most hazardous PCB congeners.

Because it is expensive to remove toxic materials from the vast amount of sewage that passes through treatment plants, the EPA has separate pretreatment regulations to control the discharge of 110 toxic chemicals into sewage systems. In practice, a sewage district may test sewage from industries known to pollute, or the companies may certify that they have plans for preventing pollution. Ralph Erickson, the pretreatment and waste acceptance coordinator at the Madison, Wisconsin, treatment plant, says certification should reduce the need for costly testing. He admits it raises the possibility of midnight dumping. However, he says, "attitudes have changed over the decades. It used to be that nobody thought about what was put down the drain. Today . . . we have numerous firms that don't need a permit, but ask us to walk through their facilities" to evaluate the chance of toxic material entering the sewer.

Metals. The EPA took what it called a "risk-based" approach to regulating the 10 heavy metals--including lead, cadmium, zinc, mercury, and copper--it found most frequently in the late 1980s national survey. (Chromium was later deleted due to scant evidence for its toxicity, so part 503 now regulates nine metals.) The EPA postulated 14 pathways by which each metal could move from the biosolids into a person, plant, or animal. Then the agency determined which pathway would be most hazardous, and used that to set the lifetime soil "loading rate" for each metal. When the loading rate is reached, biosolids applications must cease. Part 503 also set ceilings on annual loadings of each metal, and on metal concentration in each biosolids application. Taking lead as an example, the lifetime loading on any field is 300 kg/ha, the maximum annual application is 15 kg/ha, and biosolids "sold or given away in a bag or other container" cannot contain more than 840 mg/kg of the metal.

Pretreatment is also reducing metal content. Between the national surveys of biosolids in the late 1970s and the survey from the late 1980s, the average lead level decreased from 969 mg/kg to 134 mg/kg. Nickel levels decreased from 135.1 mg/kg to 42.7 mg/kg, and cadmium levels from 69.0 mg/kg to 7.0 mg/kg. Bucking the trend, mercury levels rose from 2.8 mg/kg to 5.2 mg/kg, and arsenic levels from 6.7 mg/kg to 9.9 mg/kg.

Air and Water Pathways. From a human health standpoint, the real potential threat arises not when a pollutant enters the soil, but when it enters water, air, or food. To prevent runoff in surface water, the EPA and states regulate the slope and location of biosolids applications, and generally forbid application to frozen soil, where runoff is likely. A good, but expensive, method for eliminating runoff is to inject liquid biosolids under the soil surface. At mine reclamation sites, where applications tend to be heavier, berms may be used to trap runoff before it reaches surface waters.

To protect groundwater, the Madison, Wisconsin program has annually tested as many as 750 private wells near its application fields for the past 20 years. The major concern is nitrate concentrations, which were elevated before the program began--roughly 35% of private wells have levels above 10 milligrams per liter. However, the district's tests have not found indications that biosolids are raising that level. Indeed, substituting biosolids for commercial nitrate fertilizer could reduce nitrates in groundwater. In studies conducted at the University of Wisconsin at Madison that compared three years' effects of biosolids, dairy manure, and commercial fertilizer on nitrate concentrations in water percolating through the soil, "commercial fertilizer was consistently higher" in concentrations than biosolids and manure, says Taylor.

Tests for airborne toxic chemicals at the Texas site that receives New York City's biosolids have

Greetings

Continued from page 1

anel, a community outreach rogram, the introduction of a ew management team at the lant, and the continuation of an xtensive investment program at NYOFCo designed to minimize dors.

NYOFCo has been making aluable progress on all fronts.

You'll see that this newsletter ncludes a brief report on the first hree meetings of the Community elations Panel.

Also, I have continued to ake myself available for presen ations before interested commu ity organizations. I always stand eady to answer questions from he community and I have en aged in continuing, constructive ialogues with many responsible ocal officials and community eaders.

Our new management team ontinues its dedicated efforts to inimize odors and make sure YOFCo continues to operate leanly and safely.

Finally, NYOFCo's aggres ive investment initiative has al eady made noteworthy improve ents at our facility, including an nnovative air recirculation system nd the installation of a series of ydraulic valves on the plant's egenerative thermal oxidizers RTO), the purifying "ovens" hat help ensure the quality of the ir coming from stacks.

NYOFCo remains attentive o your concerns about odors ssociated with the plant. We ledge to keep taking steps to be esponsive to the community's vishes.

I invite you to contact me at 718-991-7417 x223 or via email t *jkopec@synagro.com* with your uestions or comments.

Sincerely,

John Z. Kopec

NEW YORK ORGANIC FERTILIZER COMPANY

Phone: 718-991-7417

UPDATE ON THE COMMUNITY RELATIONS PANEL

As part of NYOFCo's ongoing community information program, the company has re-launched a Community Relations Panel.

The primary goal of the panel is to help educate and update community representatives on the steps NYOFCo is taking to minimize odors and promote air quality in the neighborhood.

At the panel meetings, plant general manager John Kopec shares information about facility operations and responds to questions posed by community representatives.

Panel members include personnel from the office of Borough President Adolfo Carrión, Jr., Congressman José Serrano, the New York City Department of Environmental Protection, Community Board 2, and local community organizations.

Thus far this year, NYOFCo has conducted Community Relations Panel meetings on February 3, May 12 and July 28.

The facility's new recirculation system has been a primary topic at each meeting. Kopec has provided panel members with a detailed description of the recirculation process, with a focus on ways that the new system helps ensure air quality and helps reduce the possibility of plant odors.

In addition, NYOFCo officials briefed panel members on a number of neighborhood-based environmental and educational activities in which the company has been engaged.

OCEAN DUMPING BAN

Continued from page 1

City officials needed to find a quick and efficient way to phase out ocean dumping. The New York City Department of Envrionmental Protection (DEP) had used out-of-state landfills to meet an initial 1992 deadline. DEP viewed landfills as the ideal option, but they were available only for the short term.

To address this challenge, the New York City Department of Environmental Protection contracted with the New York Organic Fertilizer Company (NYOFCo) to own and operate a biosolids heat-drying and pelletizing facility in the Bronx.

In 1993, NYOFCo's Bronx plant began commercial operations. Since the facility opened, it has helped New York City meet its obligations under the federal Ocean Dumping Ban Act by converting nearly three million wet tons of biosolids into "Class A" fertilizer pellets.

Biosolid pellets produced by NYOFCo meet the "exceptional quality" standard specified under Environmental Protection Agency's sludge regulations and are used as organic fertilizer in various locations across the U.S. and overseas.

EMPLOYEE PROFILE: OMAR BARAHONA

Omar Barahona serves as Operations Manager at the NYOFCo facility. Originally from Buenos Aires, Argentina, Barahona is a naval engineer who holds a master's degree in engineering from the Merchant Marine Academy in Buenos Aires.

In 2000, Barahona left Argentina to move to the United States. He began working at NYOFCo in 2004. As Operations Manager, 45-year-old Barahona oversees the 27 employees in the department and is in charge of the plant's mechanical equipment.

His chief roles are to ensure the reliability of mechanical equipment, perform scheduled maintenance programs, optimize the operation of equipment, maintain a safe work environment, investigate process improvements and repair equipment in case of emergency. Barahona also serves as the department's administration manager, with duties including budgeting, new projects, modifications, and managing contractors' work.

One of his top priorities is to ensure the successful operation of NYOFCo's new recirculation system.

Smooth operation of the recirculation system reduces the level of nitrous oxide (NOx) emissions produced by the plant. The new system also helps the facility process biosolids for the New York City Department of Environmental Protection in a more efficient manner.

When Omar Barahona isn't busy maintaining operations at NYOFCo, he is busy maintaining the operation of his 1973 BMW, which he calls "Paco." He also enjoys swimming, carpentry and reading.

Barahona's wife, Penny, is a film producer working with the History Channel. They live in Connecticut with their son, Roman. Barahona also has four grown children who live in Argentina.

THE NYOFCo ACCESSIBILITY INITIATIVE

- New general manager and plant management team
- Extensive investments designed to minimize odors
- Systematic outreach to the community
- Community newsletter
- Re-launch Community Relations Panel

NYOFCo
New York Organic Fertilizer Co.
REPORT TO THE Community
Fall 2005

Greetings

John Z. Kopec
NYOFCo General Manager

Dear Neighbor:

On behalf of everyone at NYOFCo, I am pleased to present the second edition of our "Report to the Community."

As many of you know, this newsletter is an element of the five-part "NYOFCo Accessibility Initiative."

The initiative's primary goals are to share information with the community, keep NYOFCo accessible and responsive to the public, and help make sure NYOFCo continues to serve as a good neighbor and a good corporate citizen.

We want to make sure you know that NYOFCo is doing all we can to keep our facility operating properly and to make sure we comply with regulatory guidelines.

In addition to publishing this newsletter, other elements of the initiative include the re-launch of a Community Relations

Continued on page 2

RECIRCULATION INITIATIVE DELIVERS RESULTS

To enhance the quality of the air coming from the NYOFCo pelletization facility -- and to help minimize the potential for plant-related odors -- the company has installed a new flue gas recirculation system designed to significantly reduce the overall volume of air emissions.

NYOFCo has instituted recirculation on a pilot basis along "train four," one of the plant's six processing pathways.

By employing this recirculation strategy, the facility reuses at least 50 percent of the processed air that runs through an individual unit's drying system. This "processed air" is generated during the manufacture of organic fertilizer pellets.

By sending this processed air back for a "second run" through an evaporation furnace and a large, rotating, multi-pass drum dryer, NYOFCo decreases the amount of air that will ultimately leave the facility.

After this pilot project was completed in late March, company officials conducted a preliminary analysis of its impact on "train four" air emissions.

The initial analysis was encouraging. It found that recirculation technology had reduced the level of nitrous oxide (NOx) emissions -- a component of "smog" -- by a factor of 50 percent.

Based on these positive findings, NYOFCo plans to install a second recirculation system on "train five." If the improvement plan remains on schedule, work on the new system could begin this fall.

In addition to the recirculation initiative, NYOFCo is working in other ways to respond to community concerns about odors associated with the facility. The company has made additional progress in the area of odor containment by completing installation of a hydraulic valve system onto the plant's regenerative thermal oxidizers (RTO). RTO's are the large, purifying ovens that help ensure that air leaving the stacks is as clean as possible.

As part of the "NYOFCo Accessibility Initiative" launched earlier this year, the plant management has been regularly updating regulatory officials, members of the Communtiy Relations Panel and Community Board 2 on the progress of the recirculation project and other plant improvements.

THE OCEAN DUMPING BAN
A HISTORY

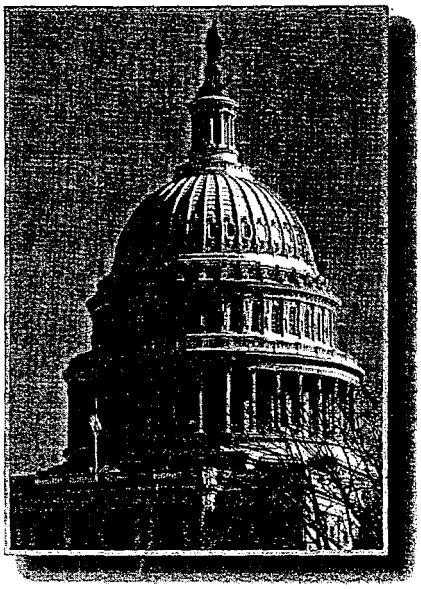
The Big Apple is home to 14 wastewater treatment plants that process 1.7 billion gallons of wastewater each day and produce between 1,000 and 1,200 wet tons of biosolids a day.

The federal Ocean Dumping Ban Act of 1988 prohibited the discharge of all municipal sludge and industrial waste into the ocean after December 31, 1991. New York City was given until June 30, 1992 to end ocean disposal.

This national legislation forced New York City to find a new way to manage the wastewater residuals produced by millions of city residents.

But the law did not only prevent the use of the ocean as a dump. It also recognized that sludge was a potential resource and not solely a waste product.

Continued on page 2



shown "no significant amount [of pathogens], either within the fields or off-site," says B.L. Harris, associate director of agricultural science at Texas Agricultural Extension Service. Similarly, Pillai reports "no indication that pathogens from the sludge application site are blowing beyond the site."

Odor. Although most people consider bad odors more of a nuisance than a health problem, continuous exposure to strong odors, for example those emanating from hog farms, has been shown to adversely effect the health of some people. Some opponents of biosolids recycling have cited odor as a primary incriminating factor. In fact, biosolids can be closer in appearance and scent to good compost than to the smelly animal manure that farmers have always used to rejuvenate their soil. And when biosolids are injected under the soil surface, the process is virtually odorless. But in northwest New Jersey, residents of Harmony Township blame sewage biosolids and other residues for the air they claim smells like diarrhea, vomit, and urine. "People should not have to live this way," says Lois Markle, a teacher and vociferous opponent of the odors, who recently was elected deputy mayor of the township. Markle blames the problem on a farm that accepts biosolids and slaughterhouse and food-processing wastes, and on a biosolids processing plant next door. With two biosolids facilities side by side, Markle charges, the "[New Jersey] Department of Environmental Protection is not [able] to figure out who is making the odor." After years of complaints, the state is suing one of the operators for air-quality violations.

Says Rubin, "The only real issue in the public acceptance arena regarding biosolids is nuisance: odor and appearance." According to him, even if a recycler or user of recycled biosolids meets the requirements of part 503, it is their responsibility to make sure they are not creating nuisance conditions and are using the biosolids in a "neighbor-friendly manner."

Food

Questions still remain, however--most prominently, how safe is food grown on biosolids-amended soils. This question, prompted by concern among food processors that the public might boycott their products, sparked the NRC study of biosolids application and wastewater reuse. In the most comprehensive report in many years on biosolids recycling, the NRC generally endorsed the EPA's approach, concluding that "while no disposal or reuse option can guarantee complete safety, the use of [biosolids and treated effluent] in the production of crops for human consumption, when practiced in accordance with existing federal guidelines and regulations, presents negligible risk to the consumer, to crop production, and to the environment." However, the committee did suggest that the EPA reconsider its exclusion of toxic organics from Part 503.

The NRC group added that as more croplands "reach their regulatory limit of chemical pollutant loading from sludge application, additional information will be needed to assess potential, long-term impacts of sludge on ground water quality and on the sustainability of soils for crop production." However, since less than 2% of total U.S. cropland would be enough to recycle all current biosolids production, and in many cases biosolids can be applied for 100 years before lifetime loading rates are reached, the day of saturation will not soon be reached.

Although the NRC committee found that there "have been no reported outbreaks of infectious disease associated with a population's exposure--either directly or through food consumption pathways--to adequately treated and properly distributed reclaimed water or sludge applied to agricultural land," some committee members remain skeptical. "I think [the committee was] too willing to accept that since there were no reported outbreaks, then everything was okay," says Baram. "Maybe we've been lucky, or maybe we have just not found causal connection--or maybe I'm being too cautious, but the area of pathogens seems to need more attention."

Given that the scientific literature contains no reports of toxicity or disease due to sludge, why does the public still seem frightened? In some cases, it's probably due to regional resentment, a feeling that easterners, or New Yorkers, are dumping their waste on the rest of the country. There is also a fundamental feeling that biosolids are unclean. When those feelings are combined with fear that

biosolids are--as, admittedly, was true 20 years ago--carrying unacceptable levels of heavy metals and toxic chemicals, it's easy to understand the "don't dump on me" sentiment. Rubin acknowledges that spills, smells, and slip-ups sabotage public confidence in land application. "If the public feels the aesthetics are bad, or a sloppy operation is going on and nobody cares, they will feel something is wrong with their health."

In trying to influence public opinion, leaders of the biosolids-to-land movement recognize that conducting tests and renaming sludge are not enough to convey a clean image. The Madison district, for example, washes its biosolids-hauling trucks daily, injects biosolids under the soil to prevent runoff and odors, and actively recruits school groups and other visitors to visit its spic-and-span treatment plant. This type of vigilance is evident in an increasing number of sewer districts, Rubin says. "There are cities that jealously guard the quality of their sludge, so as to minimize local resentment." Some, he says, are setting local pollutant limits that are more stringent than the federal rules.

David Tenenbaum

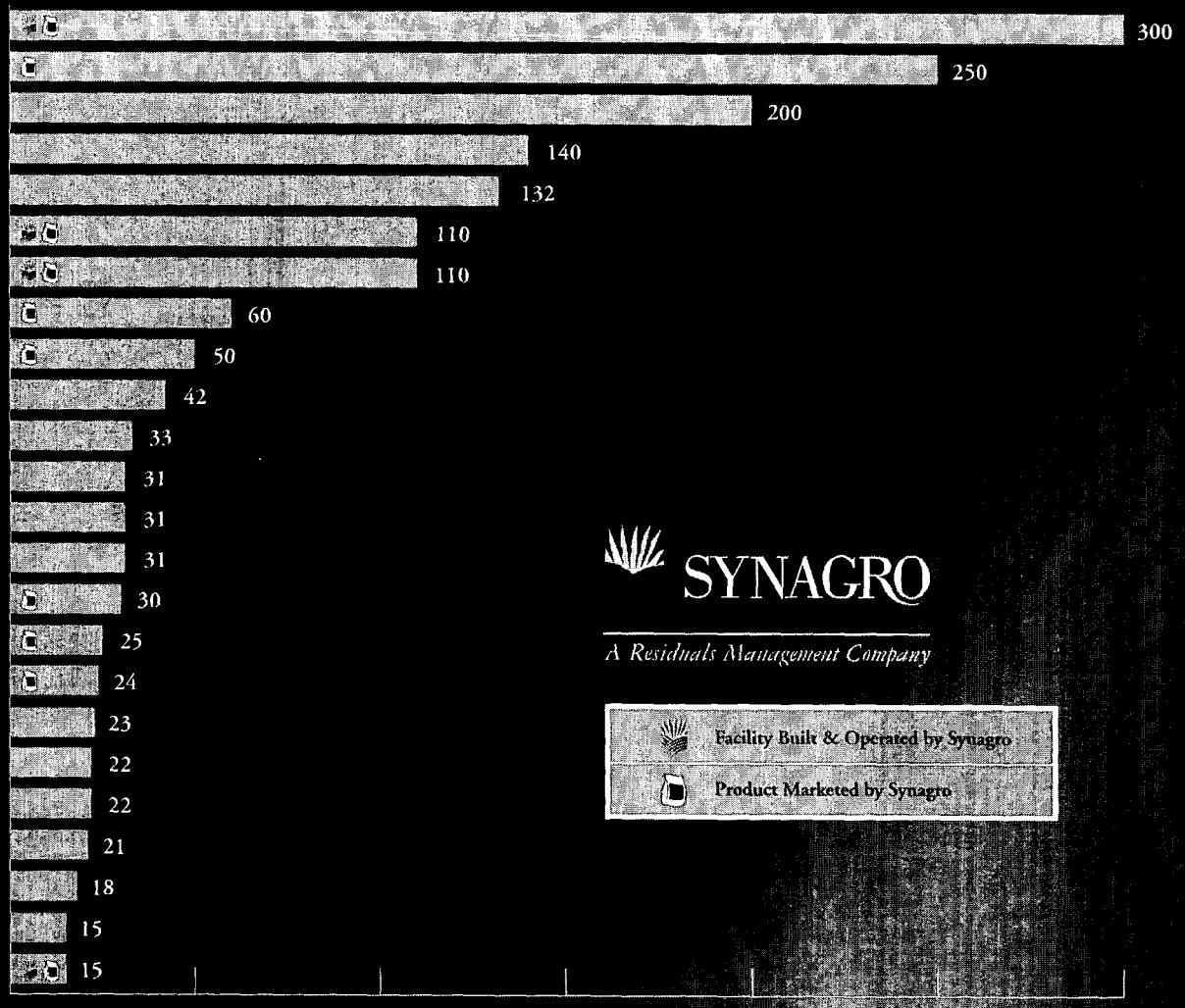
[Table of Contents]

Last Update: March 19, 1997

FACILITY DESIGN THROUGHPUT

Dry Tons Per Day

Biosolids Drying & Pelletizing Facilities



SYNAGRO

A Residuals Management Company

Facility Built & Operated by Synagro

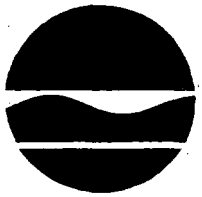
Product Marketed by Synagro

Synagro markets approximately 60% of total U.S. production

Exhibit E

See attached.

New York State Department of Environmental Conservation
Division of Air, Region 2
47-40 21ST Street, Long Island City, NY 11101-5407
Phone: (718) 482-4944 • **FAX:** (718) 482-4874
Website: www.dec.state.ny.us



Erin M. Crotty
Commissioner

November 20, 2003

Mr. Peter Scorziello
Plant Manager
New York Organic Fertilizer Company
1108 Oak Point Avenue
Bronx, NY 10474

Re: Compilation and Assessment of Available Scientific Data Report
Title V Facility Permit Condition 38

Dear Mr. Scorziello:

The Department has reviewed the report, "Compilation and Assessment of Available Scientific Data Relevant to Analyzing the Potential for Releases to the Ambient Environment of Pathogens, Bacteria and Spores from Biosolids at the NYOFCo Facility and Other Similar Facilities in the United States."

Because your facility processes biosolids to the Class A pathogen-free level per 40CFR503.30 and in accordance with the EPA guidance document, Control of Pathogens and Vector Attraction in Sewage Sludge (EPA/625/R-92/013, Office of Research and Development), the Department believes, based upon available data, pathogens should be sufficiently reduced to protect public health and the environment and no additional tests, studies or measures are required at this time. If future research concludes there are public health concerns associated with biosolids and emissions during treatment, specifically drying/pelletizing operations, your facility may be required to conduct further tests.

If you have any questions you may contact me at (718) 482-4944.

Sincerely,

Richard Fram

Richard Fram, P.E.
Environmental Engineer III

cc: Sam Lieblich, P.E., Regional Air Pollution Control Engineer

Exhibit F

See attached.

ASTHMA IN THE SOUTH BRONX
REPORT OF THE HEALTH EFFECTS GROUP

U.S. Environmental Protection Agency
Region II, New York
May 20, 1996

Demographic Analysis

During the period from 1981 to 1991, both asthma prevalence and hospitalization rates increased in the U.S. and several other countries[1]. These increases occurred most dramatically in the 0-4 year age group. The causes of this increase are unknown though most of the increase is seen in the non-white population[2]. Though mortality rates in the U.S. have risen as well, it is unclear whether mortality as a percentage of prevalence has changed.

The New York City average annual hospitalization rate for asthma from 1989 to 1991 was reported to be among the highest in the country, about four times the 1987 national average[3]. The Bronx was reported to have the highest admission rate of the five boroughs, six times the 1987 national average[3,4]. Specific zip codes in the South Bronx had the highest hospitalization rates among zip codes in the city, ranging up to six times the citywide average[3].

Mortality rates for asthma in New York City have also been found to be among the highest in the country[5]. Furthermore, this rate is not evenly distributed among ethnic populations. Asthma mortality rates in New York City were reported to be five times higher among Hispanics and three times higher among Blacks when compared to Whites[4]. In that same study, hospitalization rates for Blacks and Hispanics in New York City were reported to be five times higher than Whites.

The elevated rates of asthma morbidity and mortality are not consistent across all Hispanic sub-populations. While asthma prevalence among Mexican-American and Cuban children (age 6 months - 11 years) was comparable to non-Hispanic whites, prevalence among Puerto Rican children was found to be more than three times that of non-Hispanic whites[6].

The prevalence of asthma among children in the Bronx was also reported to be higher, specifically, in low income families. Among Hispanics alone, childhood asthma rates among families in The Bronx with incomes $< \$15,000$/year were found to be more than twice that of families with incomes $\geq \$30,000$/year[7]. The inner city poor are plagued by a host of problems which have been associated in the scientific literature with the elevated asthma rates in this population[8,9,10] (see Appendix B for a summary).

Comparable rates of asthma among inner-city poor minority populations in New York City are seen in similar populations in Chicago and Philadelphia[11,12]. This lends support to the evidence that the elevated asthma rates seen in these communities have less to do with living in New York City and more to do with being poor, being Hispanic or Black, and living in an inner-city environment.

In light of these statistics, accompanied by complaints by representatives of the school, an investigation of the asthma rates at PS48 was performed. The Medical Director of the Bureau of School Children and Adolescent Health of the New York City Department of Health performed a review of health records and monitored the students visits to the medical room for a one week period[13]. During that week, two students reported to the school nurse with complaints of asthma. According to the Department of Health, this is not unusual among New York City schools. Incidence of asthma at PS48 was found to be approximately 10%, in the range of rates at other New York City schools (3%-12%). Average daily attendance at PS48 averages 86%, again in the range of other New York City schools (85%-92%).

Potential Contributing Factors to Asthma

Asthma is a chronic condition of bronchio-constriction in response to a variety of airborne agents and is thought to be a type of allergic response. Ambient concentrations of major air pollutants are not thought to cause the chronic condition known as asthma and do not explain the increasing trend in asthma prevalence. For instance, the asthma mortality rate in Philadelphia rose from 1969 to 1991 while the concentration of major air pollutants declined substantially[12]. Additionally, measures of criteria air pollutants and air toxics in the South Bronx are not significantly different from concentrations in major portions of New York City and do not appear to explain the reports of elevated asthma prevalence in that area. However, air pollutants in ambient concentrations, specifically and in order of relative strength from strongest to weakest, $PM_{2.5}$, PM_{10}, SO_2, O_3, and NO_x, have been reported to trigger asthma attacks[14]. As is the case for several of the criteria pollutants, the indoor sources of NO_x (cooking ranges and kerosene heaters) have generally been found to be the most important contributor to the population's total exposure[14]. A host of air toxics have also been reported to trigger asthma and exacerbate symptoms[15]. Again however, indoor concentrations of air toxics which were judged to have the highest impact on asthma were reported to be two to ten times higher than outdoor concentrations[15]. Since Americans spend most of their time indoors, exposure to these pollutants from indoor (rather than outdoor) air would be expected to be a far more important contributor to incidence of asthma attacks.

Environmental tobacco smoke has also been reported to contribute to the pathogenesis of asthma. Exposure studies have reported a strong exposure-disease response[16]. Furthermore, a comprehensive literature review by the U.S. EPA reported that children's exposure to environmental tobacco smoke in the home is responsible for 150,000 - 300,000 episodes of lower respiratory infections such as bronchitis and pneumonia in young children up to the age of 18 months, 200,000 - 1,000,000 incidences of increased severity and additional asthma episodes and, 8,000 - 26,000 new cases of asthma annually[17]. Smoking is known to be more common among low-income and minority populations and may, therefore, contribute to asthma rates in inner-city populations[18].

Early exposure to allergens also appears to contribute to asthma prevalence. Individuals previously exposed to these allergens have been shown to have an increased risk of developing acute asthma during subsequent exposures[19]. In that study, 75% - 85% of asthma patients exhibited positive reactions to inhalant allergens, indicating a previous exposure to those allergens. The prevalence of asthma has been closely related to IgE levels which also suggests that asthma has an allergic basis. IgE-specific antibodies to dust mites, cockroaches, cat dander, grass, and ragweed pollen were found in patients with asthma four times as often as in controls[20]. Early exposure to dust mite allergens is reported to be an important factor in the development of asthma[21]. Such early exposures to allergens from cockroaches, mice, rats, and dust mites might be thought to be more likely among inner-city dwellers and may contribute to asthma rates in low-income inner-city populations. In fact, a study of the homes of 611 inner-city asthmatic children revealed significant levels of cockroach, cat, and dust mite allergens[22].

A variety of viruses have been shown to stimulate IgE-specific antibody responses which have been associated with asthma[23]. Such viruses are associated with induction of asthma attacks in a high percentage of cases[24,25]. Overcrowding may facilitate the spread of these asthma-associated viruses throughout the inner-city low-income population.

Lastly, there appears to be some genetic predisposition for asthma. Serum IgE levels appear to be under the control of a major autosomal codominant gene[26]. Such a genetic predisposition to asthma was found among Puerto Rican children in particular when compared to a group of non-Hispanic children[27].

CONCLUSIONS

Clearly, the rates of asthma in the South Bronx are among the highest in the country and many of the major contributing factors are known or suspected. It is not possible at this time to determine the relative contribution of outdoor or indoor air pollution to these asthma rates.

However, regardless of the contributing factors, symptom recognition and a proper regimen of medical care is the appropriate response to asthma. Provision of such health care and community education is desirable. Such services are currently being provided by the New York City Department of Health (see Appendix C for a description of those activities). Additional asthma outreach services and health care are provided in the South Bronx by other sources as well (see Appendix D for a description of those activities).

In light of the fact that high rates of asthma exist within this population, all possible efforts should be made to provide a clean air environment, both indoors and outdoors.

Principally prepared by:
Dr. Michael Buccigrossi, Asst. Chief
Radiation and Indoor Air Branch
(212) 637-4008

Additional Contact:
Paul Giardina, Chief
Radiation and Indoor Air Branch
(212) 637-4013

APPENDIX A

PREVALENCE AND HOSPITALIZATION DATA

Average Annual Asthma Hospitalization Rate

National (1987):	185	(per 100,000)
New York City (1989-1991):	681	(per 100,000)[3]
Bronx (1989-1991):	1,106	(per 100,000)

Median Annual Asthma Hospitalization Rate Among Zip Codes (1989-1991)[3]

Citywide Median:	405 - 418 (per 100,000)
Zip Codes in South Bronx: (10454 and 10456)	2,000 - 2,750 (per 100,000)

Asthma Prevalence (period of study) in Children (0-17 years) (1991)

U.S. Urban Average:	4.3% [28]
The Bronx:	8.6% [7]

ETHNICITY/RACE DATA

New York City Average Annual Asthma Hospitalization Rate by Ethnicity/Race (1989-1991)[3]

New York City Total:	681	(per 100,000)
Hispanics:	1,003	(per 100,000)
Blacks:	810	(per 100,000)
Whites:	242	(per 100,000)

Multivariate analysis in this study showed that rate of asthma hospitalization in New York City 1990 was 4.91 greater for Hispanics and 4.16 greater for Blacks when compared to Whites[3].

New York City Average Annual Asthma Hospitalization Rate by Ethnicity/Race (1982-1986)[4]

Hispanics:	62.9	(per 10,000)
Blacks:	59.9	(per 10,000)
Whites:	12.2	(per 10,000)

New York City Average Annual Asthma Mortality Rate by Ethnicity/Race (1982-1986)[4]

Hispanics:	1.3	(per 100,000)
Blacks:	2.2	(per 100,000)
Whites:	0.4	(per 100,000)

Cumulative (ever had) Asthma Prevalence in Children (0-17 years) in the Bronx by Ethnicity/Race (1991)[7]

Hispanics:	17.9	per 100
Blacks:	11.6	per 100
Whites:	8.2	per 100

Lifetime Prevalence of Reported Asthma in Children (6 months-11 years) by Ethnicity/Race (1982-1984)[6]

non-Hispanic White	6.4%
non-Hispanic Black	9.1%
Mexican-American	4.5%
Cuban	8.8%
Puerto Rican	20.1%

SOCIOECONOMIC DATA

Cumulative (ever had) Asthma Prevalence in Children (0-17 years) in the Bronx by Income Level (1991)[7]

< $15,000/year	20.3	(per 100)
$15,000 - $30,000/year	12.5	(per 100)
≥ $30,000/year	8.6	(per 100)

Cumulative (ever had) Asthma Prevalence in Children (0-17 years) in the Bronx by Income Level Within Ethnicity (1991)[7]

	Blacks	Hispanics
< $15,000/year	11.4	23.5
≥ $30,000/year	8.1	10.1

(rates shown are per 100 children)

APPENDIX B

INNER CITY STATUS RELATED TO ASTHMA
(for a full review, see refs. 8, 9, and 10)

Exposure to Environmental Allergens Associated with Asthma

- exposure to allergens from mice, rats, cockroaches, molds, and dust mites
- exposure to smoking
- exposure to irritants from faulty boilers
- crowding causes exposure to viruses

Low Birth Weight Associated with Asthma
(may be through smoking which is also related to both asthma and low birth weight or may be through mechanical respiratory problems in the infant)

- higher rates of low birth weight among innner city poor

Diminished Utilization of Health Care Associated with Asthma

- acculturation associated with utilization of medical care
- ability to speak english associated with utilization of medical care
- 30% of poor have no health insurance

Family Dysfunction Associated with Asthma

- 50% inner city children lived with mothers who were widowed, separated, divorced, or never married
- 1987 - Los Angeles - 65% inner city poor households headed by single woman
- serious family problems associated with poor inner-city populations
  - physical or sexual abuse of mother (41%)
  - drug or alcohol abuse by mate (39%)
  - drug or alcohol abuse by mother (21%)
  - mental illnes of mate (16%)
  - mental illnes of mother (8%)

APPENDIX C

BUREAU OF SCHOOL CHILDREN AND ADOLESCENT HEALTH
SUMMARY OF ACTIVITIES AT PS 48X - FEBRUARY - MARCH 1996

From February 15 through March 1, a BSCAH medical team, consisting of a Supervising Physician, a Physician, a Supervising Public Health Nurse, A Public Health Nurse, and a Public Health Assistant conducted a medical record review and an on-site assessment at P.S. 48X. The team reviewed all School Health records including the 103S (students medical record card) and 211S (physical examination form required for all newly entering students to NYC schools) and noted that approximately 140 children had been identified as having some mention of respiratory problems or a history of asthma. Through talking to parents and examining the 104S file (students health record card maintained by teachers), children who had been asymptomatic for years were eliminated. The actual number of identified children with active disease was reduced to approximately 108. (Approximately 10% of the total school enrollment)

From February 26 through March 1, the BSCAH medical team performed the following activities:

* The BSCAH Medical Director met with the principal of P.S. 48X to discuss the mission of the BSCAH medical team.

* The medical team reviewed the students' cumulative records including the students' 104S form, that is kept by the teacher.

* The Medical Director and the Supervisory medical staff participated in a meeting at the school on 2/29, which included parents, representatives of the school, the Division of Environmental Health Services of DOH, the Board of Education, and the United Federation of Teachers. Senior BSCAH staff also participated in a meeting of Bronx Community Board 2 on 2/29 with representatives from Department of Environmental Protection, Environmental Protection Agency, Department of Environmental Conservation, New York Organic Fertilizer Company, and Department of Sanitation. These meetings were held to address environmental concerns at the school and in the community respectively. The involved agencies discussed their interventions and on-going investigations.

* Monitored the students' walk-in visits or referrals to the medical room for acute or daily complaints. The total for the week was 19, of which 2 were identified as asthma and 1 was identified as congestion due to cold.

* In cooperation with the Board of Education contract nurse, reviewed the status of students that had come to that nurse's attention. Collaboration will be on-going.

* Invited parents of identified asthmatic students to attend a physician-nurse-parent conference on February 29 on the health status of their child. Twenty out of 47 parents took advantage of this opportunity. 46 parents were invited to attend a medical conference about their child on March 11. 17 parents were conferenced on that day. (Additional sessions will be scheduled as needed.)

* Compiled numbers of identified asthmatics in 13 schools in CSD #8. Rate of asthma ranges from a low of 3% to a high of 12% in individual schools. Rate of asthma at PS 48 is approximately 10% as ascertained thus far.

* Obtained attendance data from schools in the district to construct a comparative analysis with P.S. 48X. The average daily attendance for all schools ranges from 85-92% from September through January; daily attendance at PS 48 averages 86%.

Continuing Follow-Up

BSCAH plans to continue the following activities at PS 48X:

* Investigate teacher-identified students with respiratory problems reported to the principal in early February. 242 of 764 students were identified (no names given) from classroom polls. Teacher - nurse conferences will take place to identify students and to confirm by medical record review and subsequent parent conferences.

* Investigate medical history of students who significantly exceed the average absentee rate.

* Schedule parent-physician-nurse conferences for those parents who did not previously attend conferences.

* Continue on-going educational sessions for parents about asthma and respiratory illnesses. A session to be conducted by the BSCAH medical team, will be held on March 13. All parents were invited.

* Review medical records and assess students at I.S. 74, a school located two blocks away from P.S. 48X, for comparision.

* Conduct a citywide assessment to identify students with asthma-related symptoms to compile data on the rate of asthma in New York City school children.

APPENDIX D

ASTHMA HEALTH CARE AND OUTREACH ACTIVITIES IN THE SOUTH BRONX

New York City Department of Health

- Currently implementing a program to place a full-time school nurse in every school by 1997. The program is already 80% completed.
- All nurses receive an annual orientation on asthma.

Board of Education

- Has the provision to assign nurses to schools when the need arises. One such nurse has been assigned to PS48 to work with children with asthma.

Child Health Clinics

- There are 43 clinics throughout the city, including the South Bronx, which provide full primary care services, preventive care and sick care, including asthma treatment and prevention, to all New York City children between the ages of 0-13 years at no cost to the family.

American Lung Association

- The ALA implements the "Open Airways" program throughout the city including the South Bronx.
- All public schools were mailed information and outreach materials at the beginning of the school year.
- Presentations were given to students, teachers, and parents at 6 of the 28 schools in School District 8 so far this year. A presentation was scheduled at PS48 for March but was postponed until April 19th.

Research Efforts

- The New York City Department of Health and the New York Academy of Medicine are embarking on a city-wide study of asthma.

- The New York State Department of Health has submitted a proposal to EPA for a study of air pollution and asthma in New York City.

REFERENCES

1. Weiss, KB; Gergen, PJ and Wagener, DK. Breathing better of wheezing worse? The changing epidemiology of asthma morbidity and mortality. Annual Review of Public Health, 14: 491-513; 1993.

2. Weiss, KB and Wagener, DK. Asthma surveillance in the United States: a review of current trends and knowledge gaps. Chest, 98: 179S - 184S; 1990.

3. De Palo, VA; Mayo, PH; Friedman, P and Rosen, MJ. Demographic influences on asthma hosptial admission rates in New York City. Chest, 106(2): 447-451; 1994.

4. Carr, W; Zeitel, S and Weiss, K. Variations in asthma hospitalizations and deaths in New York City. American Jounral of Public Health, 82(1): 59-65; 1992.

5. Weiss, KB and Wagener, DK. Changing patterns of asthma mortality: identifying target populations at risk. JAMA, 264: 1683-1687; 1990.

6. Carter-Pokras, OD and Gergen, PJ. Reported asthma among Puerto Rican, Mexican-American, and Cuban children, 1982-1984. American Journal of Public Health, 83(4):580-582; 1993.

7. Crain, EF; Weiss, KB; Bijur, PE; Hersh, M; Westbrook, L and Stein, REK. An estimate of the prevalence of asthma and wheezing among inner-city children. Pediatrics, 94(3): 356-362; 1994.

8. Weiss, KB; Gergen, PJ and Crain, EF. Inner-city asthma: the epidemiology of an emerging US public health concern. Chest, 101(6): 362S - 367S; 1992.

9. Evans, R. Asthma among minority children. Chest, 101(6): 368S-371S; 1992.

10. Wood, PR; Hidalgo, HA; Prihoda, TJ and Kromer, ME. Hispanic children with asthma: morbidity. Pediatrics, 91(1): 62-69; 1993.

11. Marder, D; Targonski, P; Orris, P; Persky, V and Addington, W. Effect of racial and socioeconomic factors on asthma mortality in Chicago. Chest, 101(6): 426S-429S; 1992.

12. Lang, DM and Polansky, M. Patterns of asthma mortality in Philadelphia from 1969 to 1991. New England Journal of Medicine, 331(23): 1542-1546; 1994.

13. Bureau of School Children and Adolescent Health Summary of Activities at PS48 - February - March, 1996.

14. Koren, HS. Associations between criteria air pollutants and asthma. Environmental Health Perspectives, 103(Suppl. 6): 235-242; 1995.

15. Leikauf, GD; Kline, S; Albert, RE; Baxter, CS; Bernstein, DI; Bernstein, J and Buncher, CR. Evaluation of a possible association of urban air toxics and asthma. Environmental Health Perspectives, 103(Suppl. 6): 253-271; 1995.

16. Wartenberg, D.; Ehrlich, R. and Lilienfeld, D. Environmental tobacco smoke and childhood asthma: comparing exposure metrics using probability plots. Environmental Research, 64(2): 122-135; 1994.

17. Respiratory Health Effects of Passive Smoking: Lung Cancers and Other Disorders. Office of Research and Development and Office of Air and Radiation, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/6-90/006F, December 1992.

18. Radon Risk Communication and Results Study. Conference of Radiation Control Program Directors. Performed by Survey Communications, Inc., Baton Rouge; April 22, 1994.

19. Neslon, HS. The atopic diseases. Ann Allergy, 55: 441-447; 1985.

20. Pollart, SM; Chapman, MD; Fiocco, GP, et al. Epidemiology of acute asthma: IgE antibodies to common inhalant allergens as a risk factor for emergency room visits. J. Allergy Clin Immunol., 83: 875-882; 1989.

21. Sporik, R; Holgate ST; Platts-Mills TAE, et al. Exposure to house dust mite allergen and the development of asthma in children. New England Journal of Medicine, 323: 502-507; 1990.

22. Eggleston, P. National Copperative Inner-City Asthma Study. Presented at the Annual Meeting of the American Academy of Allergy, Asthma and Immunology, New Orleans, March 20, 1996.

23. Busse, WW; Lemanske, RF and Dick, EC. The relationship of viral respiratory infections and asthma. Chest, 101(6): 385S-388S; 1992.

24. Rossi OV; Kinnula VL; Tuokko H and Huhti E. Respiratory viral and Mycoplasma infections in patients hospitalized for acute asthma. Monaldi Archives for Chest Disease, 49(2): 107-11; 1994.

25. Macek V; Sorli J; Kopriva S and Marin J. Persistent adenoviral infection and chronic airway obstruction in children. American Journal of Respiratory & Critical Care Medicine, 150(1): 7-10; 1994.

26. Martinez FD; Holberg CJ; Halonen M; Morgan WJ; Wright AL and Taussig LM. Evidence for Mendelian inheritance of serum IgE levels in Hispanic and non-Hispanic white families. American Journal of Human Genetics, 55(3): 555-65; 1994.

27. Colp C; Pappas J; Moran D and Lieberman J. Variants of alpha 1-antitrypsin in Puerto Rican children with asthma. Chest, 103(3): 812-5; 1993.

28. Child Health Supplement of the National Health Interview Survey. Weitzman, M; Gortmaker, SL; Sobol, AM and Perrin, JM. Recent trends in the prevalence and severity of childhood asthma. JAMA, 268: 2673-2677; 1992.

Air Quality Testing Results for Hunt's Point Area of The Bronx

In response to community concerns about air quality in the Hunt's Point section of The Bronx, the United States Environmental Protection Agency (EPA) analyzed air quality samples taken at several locations in the neighborhood. The results of this investigation show that levels of virtually all pollutants that were tested for were below the scientific detection limit. EPA tested for pollutants that are not currently being monitored for in The Bronx.

On February 28 and 29, 1996, EPA collected samples of the ambient air outside Public School 48 (P.S. 48) and at the Port Authority Building on Oak Point Street when the wind was blowing from the direction of the New York Organic Fertilizer Company (NYOFCO). Community residents and parents and teachers from P. S. 48 had complained about strong odors from the facility. In addition, samples were collected in stainless steel canisters during the following week by local residents and by personnel at P.S. 48 and Intermediate School 74 (I.S. 74) during perceived odor episodes.

These samples were analyzed for three types of pollutants:

- Substances that produce odors -- Samples were analyzed for substances that produce odors, such as sulfur and nitrogen compounds. None of the samples contained detectable amounts of odor-causing compounds. However, it is important to bear in mind that the human nose can detect odor at levels below the level that instruments can register.

- High risk volatile organic compounds (VOCs) -- the samples were analyzed for a standard set of 21 VOCs selected because they are the compounds most likely to be found in an urban industrial setting.

- Other VOCs -- Using qualitative techniques that can detect the presence of a compound but not its exact concentration, samples were examined for a much broader list of VOCs to be certain that no other compounds were present in high concentrations. Only acetaldehyde, a relatively harmless VOC, was found at a detectable level.

A total of 25 samples were analyzed for VOCs, 4 samples for sulfur compounds and 18 for nitrogen compounds. VOCs were chosen for this air sampling study because they are likely to be emitted from the type of industrial facilities in the Hunts Point area. VOCs are chemicals that may be found in some industrial solvents, dry-cleaning fluids and as components of gasoline and vehicle exhaust.

Information on ground level ozone and particulate matter is continuously collected by permanent monitors located in the South Bronx. Levels of ground level ozone, which can cause respiratory distress and can exacerbate asthma, are above federal health-based standards. The entire New York metropolitan area and much of the eastern seaboard is out of attainment with federal ozone standards. The Bronx meets federal health-based standards for particulate matter (Manhattan does not). However, EPA is currently exploring new standards for particulate matter based on new health information.

For more information, contact Community Relations Specialists, Ann Rychlenski at 212-637-3672 or Natalie Loney at 212-637-3639; or Carlos Ramos, Special Initiatives Coordinator at 212- 637-3588.

Canister Sampling in Hunt's Point, South Bronx
February 29 - March 5, 1996
21 Target Volatile Organic Compounds

Chloromethane	<2.5ppbv*
Vinyl Chloride	<2.5ppbv
Chloroethane	<2.5ppbv
Triclhlorofluoromethane	<2.5ppbv
1,1-Dichloroethene	<2.5ppbv
Methylene Chloride	<2.5ppbv
Trans-1,2-Dichloroethene	<2.5ppbv
1,1-Dichloroethane	<2.5ppbv
Trichloromethane	<2.5ppbv
1,1,1-Trichloroethane	<2.5ppbv
1,2-Dichloroethane	<2.5ppbv
Carbon Tetrachloride	<2.5ppbv
Benzene	<2.5ppbv
Trichloroethylene	<2.5ppbv
Dibromomethane	<2.5ppbv
Bromodichloromethane	<2.5ppbv
Toluene	<2.5ppbv
1,1,2-Trichloroethane	<2.5ppbv
Tetrachloroethylene	<2.5ppbv
Ethylbenzene	<2.5ppbv
Meta & Para-Xylenes	<2.5ppbv
Styrene	<2.5ppbv
Ortho-Xylene	<2.5ppbv
1,1,2,2-Tetrachloroethane	<2.5ppbv
Meta-Ethyltoluene	<2.5ppbv

* ppbv = parts per billion by volume.
Typical minimun detection limit.

Exhibit G

See attached.

STATE OF NEW YORK
DEPARTMENT OF HEALTH

Office of Public Health II University Place Albany, New York 12203-3399

Barbara A. DeBuono, M.D., M.P.H.
Commissioner

Karen Schimke
Executive Deputy Commissioner

December 18, 1995

Ms. Charlotte Hartman and Ms. Anne Rabe
Citizens' Environmental Coalition
33 Central Avenue
Albany, New York 12210

Dear Ms. Hartman and Ms. Rabe:

Thank you for your thoughtful letter suggesting possible public health problems which may be associated with air pollution in the South Bronx. Dr. Stasiuk asked staff of the Division of Environmental Health Assessment to investigate the issues raised in your letter. We reviewed the scientific literature on these issues, obtained data from the New York State Department of Environmental Conservation (NYS DEC) and the New York City Department of Environmental Protection (NYC DEP), toured the Hunt's Point area and visited the New York Organic Fertilizer Company (NYOFCO). Although this investigation is continuing, I can report on our basic findings to date.

There appear to be odor problems in this area, which still are being investigated. However, I do not believe ambient air monitoring by the New York State Department of Health (NYS DOH) would contribute significantly to resolution of these problems. Similarly, I do not think the special blood lead testing you request is warranted, although the department strongly supports blood lead screening for all children less than six years of age, as mandated in Section 1370 of the Public Health Law and in Part 67-1 of NYS DOH regulations. We will review our heavy metals registry to evaluate the degree of screening in this area and, if need be, work with the New York City Department of Health (NYC DOH) to increase the rate of screening.

There are many possible sources of odors in the Hunt's Point area, in addition to the sewage treatment plant and the NYOFCO plant, although the size of these facilities and the distinctive smells associated with various sewage treatment operations make it likely that they have been sources of at least some of the odor problems. I understand the City had problems with the sludge dewatering facility which started operation in 1992 at the sewage treatment plant, and that these problems have been largely solved. We have also learned of the steps that NYOFCO has taken to reduce odors from sources it has identified since its startup in 1993. These measures include: adding an activated carbon adsorption system for emissions from the pellet storage and loadout facility, installing automatic controls to better control the fans that maintain negative pressure inside the facility, adding a coating step before storing the pellets, and repairing the catch basins on City stormwater runoff drains that were not trapping odors from the sewers. NYOFCO has also hired Odor Science and Engineering, Inc., to do a study of odors in the neighborhood. NYS DOH staff discussed all of these measures with NYS DEC and NYOFCO and asked the company to keep us informed on the progress of its study and other attempts to identify and control odor sources. We have also contacted NYC DEP to get more information about the notices of violation it issued to NYOFCO this summer and fall.

Your letter specifically requests that NYS DOH conduct air monitoring of the Hunts Point sewage treatment plant, the Wheelabrator pelletization plant and the Wheelabrator transfer station in the South Bronx. Air monitoring is often a very inefficient tool for identifying odors and their sources. The study by the odor consultant and establishment of a system for observation and reporting by trained individuals in the neighborhood is generally a much more powerful tool for identifying odor sources. NYOFCO appears to be making a real effort to locate local odor sources, at its facility and elsewhere, and to control those it can control. Our assessment of other possible air contaminant emissions from these major sewage-management facilities does not indicate a need for NYS DOH to conduct air monitoring at these plants, beyond what already has been done and is planned by NYS DEC and NYC DEP. In particular, the facilities are unlikely to release significant quantities of dust that may contain living micro-organisms.

The Hunt's Point sewage treatment plant is an open-air facility. The main pumphouse and the sludge dewatering centrifuges are enclosed. Since this site processes wastewater and damp sludge, there should not be significant dust generation due to waste processing at the facility. There is evidence that aerosols containing viable microorganisms can be emitted from open-air sewage treatment plants (reviewed in Hickey and Reist, 1975). Acute, self-limiting gastrointestinal disorders and skin irritation (but not respiratory effects) have been associated with exposure to sewage or sewage aerosols in epidemiological studies of wastewater workers (Lundholm and Rylander, 1983; McCunney, 1986; Clark, 1987). However, several epidemiological studies in communities near activated-sludge wastewater treatment plants have not demonstrated any association between the plants and adverse health effects in the community (reviewed in McCunney, 1986).

According to DEC, there is no sludge transfer station in the Bronx. Sewage sludge was handled at a site formerly owned by SPM Environmental and currently owned by Waste Management, Inc. (also a company under the same parent company as Wheelabrator Technologies, Inc.), but no sludge has been processed there in about one year. Digested sewage sludge processed by the NYOFCO (also a Wheelabrator Technologies, Inc., subsidiary) pelletization plant is loaded into dump trucks at each sewage treatment plant and is driven directly to the NYOFCO site. There is no intermediate transfer or other handling of the digested sludge.

Whether or not organic dusts contain significant quantities of microorganisms and what microorganisms are present in dust depend on the source of the dust. The NYOFCO sludge pelletization plant receives de-watered sludge and treats it by heating it to over 700° F for about 30 minutes. Even though the digestion process reduces the number of pathogens by as much as a million fold, the incoming sludge may still contain significant quantities of microorganisms, particularly enteric bacteria and viruses. However, the de-watered sludge still contains about 70 - 75% water, by weight, and does not generate dust during handling. The heating process dries the sludge and kills all microorganisms present in it. Destruction of micro-organisms is confirmed by monthly testing of the pelletized sludge; tests to date have shown no detectable microorganisms. Therefore, the pelletized sludge material would not be a significant source of live Aspergillus fumigatus or any other microorganism.

The NYOFCO facility is designed to minimize the release of dust, combustion-generated air contaminants and odors to the outside air. The entire pelletization process, including off-loading sludge from trucks, is enclosed in a building under negative pressure relative to the outdoors. Fans draw the indoor air (and fresh, outdoor air) into the gas-fired heaters, through the sludge dryers and then through pollution-control devices (bag-house and cyclone venturi scrubber for

particulates and a high-temperature thermal oxidizer for volatile organic compounds) before release outside of the plant. This is intended to control emissions of odors, dusts and aerosols generated by materials handling within the plant and by sludge drying and pelletization. Since startup of the plant in 1993, NYOFCO has made changes to improve the maintenance of negative pressure and to control dust and odors from the storage silos.

NYC DEP has sampled air contaminant emissions from the pelletization plant. Emissions were tested for lead and several other contaminants. Lead emissions were below the limit of detection (which equated to a discharge rate of 0.00078 pounds per hour). Additional stack tests will be performed in 1996. NYS DEC ambient air monitoring data in New York City also show that ambient levels of lead have decreased tremendously in the last ten years, as leaded gasoline was phased out. If you want more information on the results of the emission tests at the pelletization plant or ambient air monitoring results, you can contact Mr. Richard Fram at NYS DEC Region 2, 47-40 21st Street, Long Island City, New York 11101 (telephone, (718) 482-4944).

Your letter suggests that air contaminant emissions from the sewage treatment plant, sludge transfer, and the sludge processing pose risks similar to those of composting and of agricultural occupations. However, the reports you cite concerning the latter activities are not applicable to sewage sludge operations in the Hunt's Point area; sludge differs from compost, it is not known to contain aspergillis. The report you cite by Kramer et al. (1989) of a case of allergic broncho-pulmonary aspergillosis in an individual who lived within 250 feet of an open-air municipal leaf-composting facility asserts that composting facilities should be located greater than two miles from residential areas. There is no information in the paper providing a basis for this assertion. The A. fumigatus levels reported in Kramer et al. (1989) from the patient's house and from other sites within 1.5 miles of the compost site were well within background ranges reported in the literature (Millner et al., 1980: Jones and Cookson, 1983; Passman, 1983; NYS DOH, 1994). That is, even at a distance of only 250 feet from the composting site, the data presented in Kramer et al., provide no evidence of A. fumigatus exposure elevated above background. These sampling data are severely limited because samples were only collected on one day and no attempt was made to compare sites upwind and downwind of the compost facility, nor was sampling done at any control sites.

In general, there is not sufficient evidence to unequivocally state a precise distance at which there will be no increased bioaerosol exposure from compost-facility emissions. What evidence has been obtained suggests that compost-related bioaerosol levels downwind from open-air facilities return to background levels within a few hundred meters from the facility boundary (Millner et al., 1980; Passman, 1983; NYS DOH, 1994). The studies by Passman and Millner showed A. fumigatus values in the background range between 100 and 200 meters downwind of sewage-sludge composting facilities. Our study of the Islip yard-waste composting facility showed that average A. fumigatus levels downwind of the facility, at a distance of 540 meters, were about two-fold higher than the average background level, but this difference was not statistically significant. There was no evidence from our study that this level of compost-related bioaerosol exposure was associated with any increase in the incidence of health symptoms.

The data from Kramer et al., Millner et al., Passman and our study pertain to open-air composting sites. Active composting is a well-known source of A. fumigatus and thermophilic actinomycete bacteria. By contrast, essentially no bioaerosols emissions would be expected from the NYOFCO sludge pelletization plant because, as discussed above, the process there does not involve proliferation of microorganisms, but includes a heat treatment which kills them.

In addition, the process is completely enclosed under negative pressure and all air vented from the plant passes through pollution-control equipment.

The Centers for Disease Control and Prevention/National Institute of Occupational Safety and Health alert (NIOSH, 1994) to which you refer was specifically concerned with worker exposure to organic dusts contaminated with microorganisms. The particular focus of the alert was preventing Organic Dust Toxic Syndrome (ODTS) which is an occupational respiratory disease among people "exposed to heavy concentrations of organic dust contaminated with microorganisms" (NIOSH, 1994). This disease is mainly found among agricultural workers exposed to dusts from microbially-contaminated materials such as cotton, flax and other plant fibers colonized by microorganisms: moldy hay or grain and dust in livestock buildings (Rylander and Musk, 1991). A report of one case of ODTS in a worker shoveling composted wood chips and leaves is mentioned in the NIOSH alert. ODTS is associated with very large exposures to materials heavily contaminated with microorganisms. Such exposures would be very unlikely in residential areas, and certainly not from the sludge pelletization or sewage treatment plants. The component of dust responsible for ODTS is still a matter for active research. Fungi, and specifically A. fumigatus, may or may not be significant agents for most ODTS-affected individuals.

As discussed above, the pelletization plant is not a likely source of dusts or microorganisms. Aerosols produced by the sewage treatment plant could include enteric bacteria and viruses, protozoans, helminth ova and fungi (Straub et al., 1993). Of these groups, the microbes most likely to cause adverse respiratory effects include gram negative bacteria (includes enteric organisms and others), fungi and viruses. Gram negative bacteria contain endotoxin in their cell walls. This is a potent respiratory inflammatory agent which could play a role in the sequence of events which leads to sustained bronchial hyper-reactivity in allergenic asthma (Duff and Platts-Mills, 1992), although there is apparently little direct evidence for this (Rylander and Musk, 1991). Respiratory viral infections can trigger asthma attacks (Duff et al., 1993; Platts-Mills, 1994) but it is not known if inhalation of enteric viruses could have similar effects. However, as noted above, four studies in communities near sewage treatment plants failed to find any association between sewage-related bioaerosol exposure and adverse health outcomes (reviewed in McCunney, 1986).

The recommendations from our Islip Composting Facility study for further study of bioaerosol exposure and its effect on allergic respiratory disease pertained specifically to composting facilities. These sites would be expected to be much greater sources of respiratory allergens than would sludge pelletization or sewage treatment plants.

Your letter suggests that children may have high lead exposure from ingestion of soil contaminated from sludge. I do not believe your assessment of such exposure is persuasive, as to either the relative importance of sludge in the child's environment or the amount of soil ingested by children. The discussion above indicates that sludge is not likely to be a major component of dust in the neighborhood.

The question of how much soil and dust children ingest is difficult to answer, and is not an important element in assessment of South Bronx air contaminant issues. There are a number of published studies of soil and dust ingestion rates. The Stanek and Calabrese (1995) study you cite is the most recent effort by these authors to reanalyze data first published by Calabrese et al. in 1989. The recent paper relies on a number of assumptions regarding food intake, gastrointestinal absorption of tracers and fecal output which result in considerable uncertainty

in the estimates of childhood soil ingestion rates. The eight different tracer elements they analyzed also yield widely differing estimates. Additional uncertainty in deriving an estimated annual soil ingestion distribution from a study that only lasted eight days arises from the assumptions that children ingest outdoor soil each day of the year, that soil ingestion is log-normally distributed and that soil ingestion over the course of a year is similar to the soil ingestion that was estimated to have occurred over eight days in September and October, when the samples were collected. If you wish to discuss this issue further, I suggest you call Bob Chinery at 458-6409.

In summary, I do not believe additional emissions testing or ambient air monitoring in the vicinity of these facilities is necessary, although there must be a continued effort to identify and control local odor sources. Previous stack testing detected no lead emissions from the pelletization plant and the nature of that plant is such that viable particles are not likely to be emitted. In addition, adverse health effects have not been found in epidemiological studies of communities near sewage treatment plants. Furthermore, without the likelihood of these plants being a common source of both lead and asthmagenic emissions, there does not appear to be a special need to screen children with respiratory problems for lead. However, all children under the age of six should have blood lead tests, and those who live in older, deteriorated housing have been shown to be at greater risk of lead poisoning.

We are still in the preliminary design stage of the proposal we are developing to investigate possible associations between ambient air contamination and asthma in the South Bronx. Decisions regarding technical details, such as the specific analytes and the location of air monitors will be based on the scientific literature on respiratory disease, available air sampling technology, local statistics on asthma attack rates, and other, practical considerations; there are many advantages to installing the additional air monitoring equipment at existing DEC air monitoring stations. We will send you a copy of our draft proposal when it is ready and would welcome your comments.

I hope the above information answers your questions. I will seek your comment on our asthma study design when it is complete. In the meantime, if you have questions about this letter, you can call John Hawley at 458-6438.

Sincerely,

Nancy K. Kim

Nancy K. Kim, Ph.D.
Director
Division of Environmental Health
Assessment

95307PRO0430

bcc: Art Fossa
Commissioenr Gelber (DEP)
Enid Carruth (NYC DOH)
John Hawley
Ed Horn
Dan Luttinger
Bob Chinery

REFERENCES

Calabrese, E.J., R. Barnes, E.J. Stanek, H. Pastides, C.E. Gilbert, P. Veneman, X. Wany, A. Lasztity and P.T. Kostecki. 1989. How much soil do young children ingest: An epidemiologic study. Regulatory Toxicology and Pharmacology. 10:123-137.

Clark, C.S. 1987. Potential and actual biological related health risks of wastewater industry employment. J Water Poll. Cont. Fed. 59:999-1088.

Duff, A.L. and T.A.E. Platts-Mills. 1992. Allergens and asthma. Ped. Clin. N. Amer. 39:1277-1291.

Duff, A.L., E.S. Pomeranz, L.E. Gelber, G.W. Price, H. Farris, F.G. Hayden, T.A.E. Platts-Mills and P.W. Heyman. 1993. Risk factors for acute wheezing in infants and children: Viruses, passive smoke and IgE antibodies to inhalant allergens. Pediatrics. 92: 535-540.

Hickey, J.L.S. and P.C. Reist. 1975. Health significance of airborne microorganisms from wastewater treatment processes. Part I: summary of investigations. J. Water Poll. Cont. Fed. 47:2741-2757.

Jones, B.L. and J.T Cookson. 1983. Natural atmospheric microbial conditions in a typical suburban area. Appl. Environ. Micro. 45:919-934.

Kramer, M.N., V.P. Kurup and J.N. Fink. 1989. Allergic bronchopulmonary aspergillosis from a contaminated dump site. Am. Rev. Resp. Dis. 140:1086-1088.

Lundholm, M. and R. Rylander. 1983. Work related symptoms among sewage workers. Br. J. Indus. Med. 40:325-329.

McCunney, R.J. 1986. Health effects of work at waste water treatment plants: a review of the literature with guidelines for medical surveillance. Am J. Indus. Med. 9:271-279.

Millner, P.D., D.A. Bassett and P.B. March. 1980. Dispersal of Aspergillus fumigatus from sewage sludge compost piles subjected to mechanical agitation in open air. Appl. Environ Micro. 39:1000- 1009.

NIOSH. 1994. Alert: Request for assistance in preventing organic dust toxic syndrome NIOSH/CDC April, 1994 alert. Cincinnati, OH. DHHS (NIOSH) Pub. No. 94-102.

NYS DOH. 1994. A prospective study of health symptoms and bioaerosol levels near a yard waste composting facility. Center for Environmental Health. Albany, NY. Doc. No. 33350299.

Passman, F.J. 1983. Recovery of Aspergillus fumigatus aerospora from municipal sewage sludge composting operations in the state of Maine. Mycopathologia. 83:41-51.

Platts-Mills, T.A.E. 1994. How environment affects patients with allergic disease: indoor allergens and asthma. Ann. Allergy. 78: 381-384.

Platts-Mills, T.A.E., M.D. Chapman, S. Pollart, C.M. Luczynska and G.W. Ward. 1991. Specific allergens evoking immune reactions in the lung: relationship to asthma. Eur. Respir. J. 4 (Suppl 13): 68s-77s.

Rylander, R. and B. Musk. 1991. Workshop on health effects of grain and other organic dusts. Committee on Organic Dusts, ICOH. Report 2/91.

Stanek, E.J. and E.J. Calabrese. 1995. Daily estimates of soil ingestion in children. Environmental Health Perspectives. 103(3): 276-285.

Straub, T.M., I.L. Pepper and C.P. Gerba. 1993. Hazards from pathogenic microorganisms in land-disposed sewage sludge. Rev. Environ. Contam. Toxicol. 132: 55-91.

Exhibit H

See attached.

Safety & Health Management Statement

Every employee is entitled to a safe and healthy place in which to work.

It is management's objective to provide the safest possible conditions for our employees. It is the basic responsibility of all supervisors to make the safety of people a part of their daily concern. Each individual who conducts the affairs of the Company, no matter in what capacity he/she may function, must accept this responsibility.

It is sound business for this Company and all its employees to eliminate employee injuries and equipment accidents. It is also sound business to eliminate all procedures and conditions that could injure personnel, damage material, equipment or property, or interrupt work schedules. Synagro management expects that our employees will not take unnecessary risks and immediately notify their supervisors of identified conditions or actions that may be considered hazardous.

Synagro subscribes to these principles:

1. *Workplace injuries are preventable through implementation of effective Safety and Health Policies and Programs supported by the total commitment of every employee of Synagro.*
2. *Accident prevention is good business. It increases productivity and minimizes human suffering.*
3. *Synagro is committed to providing a safe workplace for employees as is reasonably achievable.*
4. *Employees are responsible for being alert, following safe work practices and company rules and preventing accidents and injuries.*
5. *Synagro will monitor company safety performance, working environment and conditions to promote the achievement of safety objectives.*

The management of Synagro wants each and every stakeholder to know it is our policy that everything within reason shall be done throughout the company to maintain or improve our safety efforts. It is the expectation of Synagro management that all of our endeavors will include thoroughly evaluating potential risks and implementing necessary actions to protect the public, employees and our property and equipment. Together, we can make the difference.

Ross Patten, Chairman & CEO	Randall Tuttle, President Operations Division	Mark Weidman, President Processing Division

EHST Responsibility

I. INTRODUCTION

Synagro accepts the ultimate responsibility for providing resources and guidance for the development and implementation of the Environmental, Health, Safety and Transportation (EHST) Program, assisting EHST Managers, and establishing management policies and procedures toward effective implementation of the Company's EHST Plans and Programs.

II. GENERAL RESPONSIBILITIES

Senior management is responsible and will be held accountable for the overall implementation of the EHST plans and programs. The senior management has the authority to delegate any or all portions of the Program to subordinates. Each person, however, shall be held responsible for the implementation of this Policy. Management personnel, EHST Managers, and Supervisors have the duty and authority to approve and carry out all disciplinary actions for those who violate the policies, procedures and/or rules and regulations relating to this EHST Policy and Program. Supervisor responsibilities and duties are explained in greater detail on the following pages.

Each employee of the Company is responsible and will be held accountable for their commitment to abide by the policies, procedures, rules, regulations and orders established in this EHST Program. Each employee must become actively involved in this program to assist the Company in maintaining a safe and healthful workplace environment for all involved.

This program, as covered in this manual, describes performance standards applicable to all Company employees and locations. Local practices requiring more detailed or stringent rules, or local, state or other federal requirements regarding this subject can and should be added as an addendum to this procedure. In addition, OSHA requires site-specific procedures be developed and implemented for many of its standards (examples: lockout/tagout, hearing conservation, etc.). These site-specific procedures will be available at each site as well as a copy of each maintained by the Region/Plant ESHT Manager. Applicable employee responsibilities relating to safety and health are explained in greater detail on the following pages.

III. AUTHORITY & ACCOUNTIBILITY

A. Region/Plant EHST

Each Region and designated groupings of Plants will have a full-time employee assigned as the ESHT Manager. The EHST Manager will be responsible for the overall implementation of the Company's environmental (non-biosolids), health, safety and transportation program. The EHST Manager will exercise these procedures by identifying hazards on the worksite or working conditions that are unsanitary, hazardous or dangerous to employees and take steps to control or eliminate them immediately.

Each EHST Manager must demonstrate competency in safety and have specific training in and/or be knowledgeable about the implementation of the Company's safety and health policies as outlined in this program. They should be knowledgeable about safe operating procedures specific to Synagro, and the applicable federal, state and local safety and health

EHST Responsibility

standards required in maintaining a safe workplace. The EHST Managers are also responsible for monitoring and reporting the results as measured by criteria such as incident rates to senior management personnel.

Responsibilities of the EHST Manager shall include; but shall not be limited to:

1. Resolve questions about environmental, health, safety and transportation by directing them to local management for resolution.
2. Make regular office, shop and job site visits and safety inspections to determine if safe work practices are being observed; that required training is being performed; and to ensure that unsafe conditions do not exist.
3. Actively promote and follow their location's EHST program.
4. Closely monitor project and plant environmental, health, safety and DOT transportation compliance with all permit requirements, applicable laws and regulations and Company policies.
5. Personally perform certain safety inspections, and review safety inspection reports, supervisor investigation reports and unsafe conditions reported by Supervisors, employees or others. Make or obtain corrections as required to maintain a safe workplace and ensure compliance.
6. Ensure compliance with safe work practices and company safety rules. This includes safe working procedures in all departments.
7. Review reports of first aid incidents to determine preventive actions. Ensure that recordable injuries are being documented on Federal (OSHA 200) and State mandated accident logs as applicable.
8. Ensure that site-specific programs (i.e. hazard communication, personal protective equipment, lockout/tagout, protection from bloodborne pathogens, respiratory protection, confined space entry, industrial truck safety, etc.) are implemented and complied with at each location.
9. Maintain necessary employee safety information sources including both State and Federal postings and the ongoing maintenance of the Employee Information Board set up in a conspicuous area.
10. Develop and maintain an effective Safety Committee consistent with local, state and/or federal requirements for each Synagro Region and Plant location. The EHST Manager and/or their designee must attend each meeting, assuring the documentation of minutes and providing a report to local management following each meeting regarding loss trends / problems, issues addressed and recommended actions.
11. Ensure trucking subcontractors have signed Synagro contracts, have adequate insurance and randomly spot check subcontractor compliance with Federal or state (as applicable) DOT Regulations.
12. Observe Company and subcontractor trucking operations to ensure vehicles are being operated safely, that trailers are locked and loaded safely and that on-road equipment projects a satisfactory image to the clients and general public.

13. Educate management employees on the PACT (Prevention, Assessment, Corrective Action and Training) Program, which is the foundation for the Company's EHST and Compliance Program.

14. Use the Caribou Software to: (1) document the completion of periodic EHST tasks required by permits, regulations and Company SOP; and (2) to document the existence and planned resolution of open compliance issues.

15. Accident and Injuries:

a. Reported to the insurance carrier within 24 hours;
b. Are promptly and thoroughly investigated and appropriate corrective action is taken;
c. That injured employees are returned to the work place as soon as is practical;
d. That open communication with claims adjusters is maintained to make sure timely and appropriate attention is applied to Company incidents;
e. Supervisors deal with any negligence on the part of an employee appropriately.
f. That statistics, reports, records and files are maintained at the Plant and Region levels.

B. Supervisor Safety Responsibilities

Supervisors over each department, and any other Supervisors with authority to direct the work and actions of others, shall be responsible for adhering to all safety rules, procedures and policy guidelines.

Additionally, Supervisors must be concerned about the safety and welfare of fellow employees at work. Consequently, if a Supervisor identifies a hazard or safety compliance violation in an area outside of his or her direct authority, he or she shall report this to the Supervisor in charge of the work area and then to the EHST Manager.

If the hazard or violation presents an IMMEDIATE DANGER to life or health, the Supervisor observing the danger shall intervene immediately to the extent necessary to prevent injury or harm to persons without causing danger to him/her self. This is the primary and overriding priority. Preventing damage to Synagro facilities and/or property is a secondary priority. Therefore, any hazards requiring abatement which are outside the Supervisor's authority and/or ability to correct or eliminate, shall be immediately reported to the EHST Manager and/or Facility Management.

A Supervisor's safety performance will be part of their overall performance evaluation. Their job responsibilities include, but are not limited to:

1. Ensure compliance with project and plant safety rules and regulations through daily supervision of workers. Take corrective and, if necessary, disciplinary action to ensure employee compliance with safety policies.

2. Conduct and/or assist in safety indoctrination and training for new employees regarding department safety practices and potential hazardous conditions within the assigned work area. This includes ensuring that Personal Protective Equipment is either issued or available to new hires and they are properly trained in its use.

3. Conduct and/or assist with ongoing safety indoctrination and training for Facility employees and for personnel used on a temporary basis and provide additional safety training for employees reassigned to new duties. This means making sure that employees have received required safety training ***BEFORE*** they begin performing duties in the company workplace.

4. Report and, if possible, correct unsafe conditions anywhere they are observed in the workplace. Request corrective actions through higher levels of supervision when the required correction is beyond his/her authority or ability to correct.

5. Encourage and ensure that all accidents, injuries and "near misses" are reported by employees immediately. Take action, as necessary, when this is not done.

6. Investigate all reported accidents and "near misses". Complete the Supervisor's Report of Accident/Injury Form and distribute it to the EHST Manager. This report must document circumstances relative to all injuries or accidents involving employees, the public, a contractor or Synagro property / equipment whether owned, leased or borrowed. This must be done within 24 hours of being notified by the employee or other person involved. (Note: This is the same 24 hour period during which the incident has been reported to the EHST Manager and the EHST Manager has reported the claim to the insurance carrier.)

7. Ensure that all injuries are promptly treated by first aid. If the employee requires the attention of a doctor (non-emergency), ensure that he or she is directed to a designated primary care physician or hospital emergency room. If an employee does not or cannot drive him/herself, it is the supervisor's responsibility to arrange for suitable transportation to the local medical emergency facility.

8. All Supervisory personnel must set an example by personal behavior, such as wearing required Personal Protective Equipment and complying with the safety policies, procedures, rules, regulations and orders outlined in this program. Supervisory personnel, who fail to demonstrate, support and encourage compliance with the Company's endeavors to maintain a safe and healthful workplace environment will be subject to disciplinary action.

C. Employee Safety Responsibilities

The health and safety of each employee on the job is a major responsibility. Therefore, all employees share this obligation. Employees must make every initiative to protect their own safety and that of their fellow workers. Employees must know and follow the safe and proper procedures and be aware of the hazards related to their job. Employees must at all times use the proper personal protective and other safety equipment provided.

As a condition of employment, employees must become familiar with, observe and obey Company rules and established policy for health, safety and preventing injuries, property and

equipment damage while at work. Additionally, employees MUST learn and understand the approved safe practices and procedures that apply to their work. Every employee's job responsibilities include, but are not be limited to:

1. Before beginning special work or new assignments, employees must review applicable and appropriate safety rules.
2. If an employee has any question about how a task is to be done safely, he or she is under instruction NOT to begin the task until they discuss the situation with a Supervisor.
3. If, after discussing a safety situation with an immediate Supervisor, an employee still has questions or concerns remaining which have not been answered, he or she is required to contact the Region or Plant EHST Manager.
4. Unsatisfactory answers and/or additional concerns shall be directed to the Project or Plant Manager.
5. It is of utmost importance that employees immediately report any hazardous conditions, unsafe practices or improperly functioning equipment in the work area. Only by constant attention and quick reporting by all employees will the Company be able to eliminate hazards, prevent accidents, and make this the safest possible place of employment.
6. NO EMPLOYEE IS EVER REQUIRED to perform work that is unsafe.
7. Everyone who has agreed to work for the Company implicitly agrees to:
   a. Follow all safety rules and procedures and ask questions about any part of the job not understood.
   b. Be responsible for his/her own safety and the safety of fellow employees.
   c. Participate in safety training and education on a regular basis.
   d. Report all injuries/incidents to Supervisory or EHST personnel no matter how minor.
   e. Regard safety as an important part of getting the job done.

D. Contractors and Temporary Employees

Contractors working on Company premises or performing truck hauling operations for Synagro are responsible for ensuring that all employees and services provided by the contractor's employees, are performed in a manner that is consistent with local, state and federal requirements including OSHA, DOT, EPA and Synagro's commitment to safety and health.

Initial orientation training as well as appropriate Synagro procedures and policies must be made available to all contractors and temporary employees. Management of Synagro, acting as a Host Employer, maintains the right to request, from any contractor and temporary personnel provider, a review of their safety plan for the work to be performed. The contractor's safety plan must meet all safety and health standards required to perform the proposed work in order to comply with local, state and federal safety and health standards and maintain a safe and healthful workplace environment.

PACT – The Safety and Compliance Assurance Program

I. INTRODUCTION

The PACT program has four elements – Prevention, Assessment, Corrective Action, and Training. What follows is a description of each of these elements in a short, bullet format listing what the Company has established under each of the elements to provide a safe and healthy work environment as well as to comply with regulations. Following that listing is a description of how PACT is to be implemented in the Operations and Processing Groups.

Environmental (biosolids and non-biosolids), health, safety and transportation regulatory requirements (federal, state and local) associated with our biosolids/residual management industry have increased and are becoming more complex over time. A strong compliance assurance program is essential to insure that regulatory, permit, Company SOP and client requirements are adhered to in order to build and maintain employee and public confidence in and acceptance of the land application and processing of these recyclable materials. The PACT program contains the Company's instructions to attain and to maintain the highest level of compliance and employee and public safety.

P = To Prevent safety and compliance issues from happening

A = To Assess (evaluate) that safety and compliance requirements are being met

C = To apply Corrective actions(s) to identified safety and compliance issues to not only resolve them but also to prevent them from recurring

T = To make sure that all employees are provided effective Training to properly carry out their many, varied job responsibilities

II. LISTING OF PACT PROGRAM COMPONENTS

P = Prevention

- EHST responsibilities are included in job descriptions
- Federal, State, local, company and client EHST requirements are identified and incorporated into a compliance assurance system that includes:
  - Use of computerized Compliance Management System (CMS) that is part of the Caribou software program to list periodic compliance requirements, when they are to be done and who is responsible at each project and facility for completing each requirement.
  - Pre-Operating Checklists (land application operations).
  - Company EHST SOPs.
  - EHST Monthly Training and Inspection Checklists.
- Bonus/incentive awards

PACT – The Safety and Compliance Assurance Program

A = Assessment

- Safety and compliance assessment responsibilities are detailed in employee job descriptions.
- EHST Monthly Inspection Checklist
- CMS Review
- Formal EHST on-site audits
- Informal EHST on-site inspections/visits
- Compliance issues are entered into Caribou's Compliance Action Reporting system (CARS) for tracking purposes
- Incident Reporting/Investigation

C = Corrective Action

- Entry of compliance issues in CARS including assigning a responsible party, identifying the root cause, corrective and preventive actions and setting deadline for resolution.
- Monthly review of unresolved CARS issues at Corporate and Region level to insure each is on track for resolution by stipulated deadline.
- Disciplinary procedures

T = Training

- Job descriptions include training responsibilities.
- Training matrix identifies training required by job description.
- Training performed and documented through:

  - EHST Checklist training sessions
  - CMS Scheduled training sessions
  - Seminar attendance
  - On-site formal training as necessary
  - Video-based training topics (processing facilities)
  - Corporate and Regional Training Meetings

- Training requirements reviewed and updated as necessary

III. EHST COMPLIANCE PROGRAM (PACT IMPLEMENTATION)

The elements of PACT as described in Part II above are carried out through the Company's Compliance Program, which is described in detail below.

PACT – The Safety and Compliance Assurance Program

A. GENERAL

Activities in both the Operations and Processing Groups will use the Synagro Best Practices Manual (supplemented with site-specific policies) as the major SOP reference for management of all environmental (non-biosolids), health and safety actions. The major Company guides for biosolids/residuals compliance are the Technical Services SOPs.

B. OPERATIONS GROUP

1. Use of monthly Environmental, Health, Safety and Transportation Training Topics and Site Inspection Checklist ("Monthly Checklist" or "Monthly EHST Packet"). This contains a mandatory training topic, two informal training subjects and two site inspection checklists – one for environment (non-biosolids), health, safety and transportation and one for biosolids/residuals. Training topics and checklist content are different for each month so that by year-end, projects and shops that have completed them have accomplished most of regulatory and company requirements pertaining to training and inspections. Region EHST Managers insure the Monthly Checklists are getting done, training is tracked for all employees and that compliance issues uncovered during inspections or informal training sessions are entered into CARS by both the EHST Manager and Technical Services Director (TSD). The Monthly Checklist is not applicable to projects that start and end within a six-month period. Checklist use will be examined during audits and visits (discussed below).
2. The Pre-Operating Checklist will be the primary compliance document for biosolids/residuals. The Monthly Checklist (above) supplements the Pre-Operating Checklist to insure general biosolids/residuals requirements are being met.
3. Use of annual Training Matrix. The Matrix is developed and updated annually at the corporate level. It contains the training topics required by regulations. These topics (with few exceptions) become the training topics included in the Monthly Checklists.
4. Use of Caribou – CARS software to document outstanding compliance issues that can't be corrected within 24 hours of being identified to insure each is resolved on time and preventive action has been taken to prevent recurrence. Issues are identified as to the source (self-identified by project/shop, Company inspection, audit, or regulatory inspection). Only corporate EHST or Technical Services can approve Resolution Due Date extensions. Issues overdue for resolution are addressed quarterly with Region VP's and Corporate EHST/Technical Services staff. Root Cause and Preventive Action to be entered for all issues. CARS use will be a mandatory inspection area during EHST audits and visits.
5. Note: The implementation of Caribou CARS and Caribou CMS will not happen simultaneously. CMS will be placed into use after Caribou – CARS is being properly used throughout the Company. Estimated CMS start-up time frame is second quarter CY 2001.

Use of Caribou – CMS software to list all periodic regulatory, permit, Company and client EHST requirements (not issues!) affecting a project or shop and assignments of a completion date for each task. CMS produces a listing by month of all compliance tasks that need to be done that month. Although most tasks on a listing are periodic monthly requirements, some tasks scheduled annually, semi-annually, quarterly, every other year, etc., will be included on the monthly listing in accordance with the action schedule set up by the Region EHST and TSD in coordination with the project and shop managers.

Monthly CMS task listings will be completed for each project lasting more than 6 months and each shop. The return of completed, initialed monthly task listings to Region EHST Managers and TSD's for review and file is recommended. At a minimum, completed task listings will be retained at the operations location. CMS use will be a mandatory inspection item during EHST audits and visits (discussed below). Region EHST and TSD insure all tasks are completed in the month assigned.

Each missed CMS task does not have to be entered into CARS. If a pattern of missed tasks exists over a period of several months, this issue will be entered into CARS.

All CMS tasks are to be reviewed annually and new/updated annual tasks for projects/shops are to be issued at the end of each calendar year for use in the next calendar year.

Project Managers responsible for more than one project may use a single, consolidated, monthly CMS. If a task is unique to one project only, the project will be identified in the statement of the task. Otherwise, it will be assumed that a task is applicable to all projects under control of that Project Manager.

6. ESHT Audits (Project/Shop):
There will be 4-6 corporate audits Company-wide per year. In an Operations Group Region, an audit may look at single project, multiple projects or a combination of a project and a shop. Each audit will cover environment (biosolids and non-biosolids), safety, health and DOT transportation.

Audits are intended to be both helpful for the Project/Shop Manager and official and are used, in part, to keep Synagro management informed on the state of compliance in the Company. Each audit will last two to four days. Audit team personnel will be from the Company. The audited manager(s) will be given 30-45 days advance notice. Standardized audit protocols developed by the Company will be used.

At the conclusion of each audit, a written report will be sent to the Project/Shop Manager, Region ESHT Manager, Region Technical Services Director, Region VP, Corporate General Counsel and Group President. All issues that remain unresolved at the end of the audit will be entered into CARS.

It is the joint responsibility of the Corporate EHST and Environmental Compliance Director to schedule and staff each audit and for determining the need for post-audit re-inspections.

7. Assistance Visits:
Region EHST Managers and TSDs will conduct as necessary. Special attention will be directed at new projects and those projects/shops with known compliance issues.

Corporate EHST and Environmental Compliance Directors will visit sites from time to time outside the scope of an official audit.

Visit priorities are to first correct dangerous operating practices and then to address compliance issues. Issues that cannot be resolved during a visit will be entered into CARS and tracked until resolved.

C. PROCESSING GROUP

1. Each facility will use a weekly and monthly audit-type checklist generated from an information base listing periodic EHST regulatory and Company SOP inspection, training and reporting requirements. Each task will include the person responsible for implementation, and task completion is to be documented by the EHST Manager.
2. Site-specific safety policies and procedures will be developed and used as required. A copy of each is to be kept with the Synagro Best Practices Manual.
3. Caribou-CARS and Caribou – CMS will be employed as discussed in Operations paragraph B4 and B5 above.
4. EHST audits apply as described in paragraph B6 above. A single audit will encompass only one (not a grouping) of facilities.
5. Assistance Visits: As per paragraph B7 above.

Exhibit I

See attached.

Greetings

Continued from page 1

Panel, a community outreach program, the introduction of a new management team at the plant, and the continuation of an extensive investment program at NYOFCo designed to minimize odors.

NYOFCo has been making valuable progress on all fronts.

You'll see that this newsletter includes a brief report on the first three meetings of the Community Relations Panel.

Also, I have continued to make myself available for presentations before interested community organizations. I always stand ready to answer questions from the community and I have engaged in continuing, constructive dialogues with many responsible local officials and community leaders.

Our new management team continues its dedicated efforts to minimize odors and make sure NYOFCo continues to operate cleanly and safely.

Finally, NYOFCo's aggressive investment initiative has already made noteworthy improvements at our facility, including an innovative air recirculation system and the installation of a series of hydraulic valves on the plant's regenerative thermal oxidizers (RTO), the purifying "ovens" that help ensure the quality of the air coming from stacks.

NYOFCo remains attentive to your concerns about odors associated with the plant. We pledge to keep taking steps to be responsive to the community's wishes.

I invite you to contact me at 718-991-7417 x223 or via email at *jkopec@synagro.com* with your questions or comments.

Sincerely,

John Z. Kopec

NEW YORK ORGANIC FERTILIZER COMPANY

Phone: 718-991-7417

UPDATE ON THE COMMUNITY RELATIONS PANEL

As part of NYOFCo's ongoing community information program, the company has re-launched a Community Relations Panel.

The primary goal of the panel is to help educate and update community representatives on the steps NYOFCo is taking to minimize odors and promote air quality in the neighborhood.

At the panel meetings, plant general manager John Kopec shares information about facility operations and responds to questions posed by community representatives.

Panel members include personnel from the office of Borough President Adolfo Carrión, Jr., Congressman José Serrano, the New York City Department of Environmental Protection, Community Board 2, and local community organizations.

Thus far this year, NYOFCo has conducted Community Relations Panel meetings on February 3, May 12 and July 28.

The facility's new recirculation system has been a primary topic at each meeting. Kopec has provided panel members with a detailed description of the recirculation process, with a focus on ways that the new system helps ensure air quality and helps reduce the possibility of plant odors.

In addition, NYOFCo officials briefed panel members on a number of neighborhood-based environmental and educational activities in which the company has been engaged.

OCEAN DUMPING BAN

Continued from page 1

City officials needed to find a quick and efficient way to phase out ocean dumping. The New York City Department of Envrionmental Protection (DEP) had used out-of-state landfills to meet an initial 1992 deadline. DEP viewed landfills as the ideal option, but they were available only for the short term.

To address this challenge, the New York City Department of Environmental Protection contracted with the New York Organic Fertilizer Company (NYOFCo) to own and operate a biosolids heat-drying and pelletizing facility in the Bronx.

In 1993, NYOFCo's Bronx plant began commercial operations. Since the facility opened, it has helped New York City meet its obligations under the federal Ocean Dumping Ban Act by converting nearly three million wet tons of biosolids into "Class A" fertilizer pellets.

Biosolid pellets produced by NYOFCo meet the "exceptional quality" standard specified under Environmental Protection Agency's sludge regulations and are used as organic fertilizer in various locations across the U.S. and overseas.

EMPLOYEE PROFILE: OMAR BARAHONA

Omar Barahona serves as Operations Manager at the NYOFCo facility. Originally from Buenos Aires, Argentina, Barahona is a naval engineer who holds a master's degree in engineering from the Merchant Marine Academy in Buenos Aires.

In 2000, Barahona left Argentina to move to the United States. He began working at NYOFCo in 2004. As Operations Manager, 45-year-old Barahona oversees the 27 employees in the department and is in charge of the plant's mechanical equipment.

His chief roles are to ensure the reliability of mechanical equipment, perform scheduled maintenance programs, optimize the operation of equipment, maintain a safe work environment, investigate process improvements and repair equipment in case of emergency. Barahona also serves as the department's administration manager, with duties including budgeting, new projects, modifications, and managing contractors' work.

One of his top priorities is to ensure the successful operation of NYOFCo's new recirculation system.

Smooth operation of the recirculation system reduces the level of nitrous oxide (NOx) emissions produced by the plant. The new system also helps the facility process biosolids for the New York City Department of Environmental Protection in a more efficient manner.

When Omar Barahona isn't busy maintaining operations at NYOFCo, he is busy maintaining the operation of his 1973 BMW, which he calls "Paco." He also enjoys swimming, carpentry and reading.

Barahona's wife, Penny, is a film producer working with the History Channel. They live in Connecticut with their son, Roman. Barahona also has four grown children who live in Argentina.

THE NYOFCo ACCESSIBILITY INITIATIVE

- New general manager and plant management team
- Extensive investments designed to minimize odors
- Systematic outreach to the community
- Community newsletter
- Re-launch Community Relations Panel

Exhibit J

See attached.

SYNAGRO

A Residuals Management Company

Investor Relations

» Investor Home Page
» Stock Performance
» Stock Tracker
» Financial Fundamentals
» Presentations
» My IR Page
» SEC Documents
» Annual Reports
» Press Releases
» Printed Materials Request
» News By E-mail
» Event Calendar

» Synagro Home

Synagro Technologies Inc.

NASD: SYGR
Sector: Services
Industry: Business Services

market guide

BRIEF: For the nine months ended 30 September 2005, Synagro Technologies Inc.'s revenues increased 3% to $248M. Net loss applic. to Common totaled $18.7M, vs. an income of $3.8M. Revenues reflect increase in design build construction revenues due to a $2M increase in construction revenue on the Honolulu dryer facility project. Net income was offset by the presence of $19.5M debt extinguishment costs and stock option redemption & transaction bonuses.

OFFICERS: Ross Patten, Chairman of the Board, Vice President, Robert Boucher, Jr., President, Chief Executive Officer, Chief Operating Officer, Director, J. Paul Withrow, Chief Financial Officer, Senior Executive Vice President, Director, Alvin Thomas, II, Executive Vice President and General Counsel, Thomas Urban, Vice President-Chief Accounting Officer, Controller, TRANSFER AGENT: Intercontinental Registrar & Transfer Agent, Bo Company reincorp. DE Direct inquiries to: Director of Investor Relations

Synagro Technologies Inc.
1800 Bering
Suite 1000
Houston, TX 77057
Phone: 1-713-369-1700
Fax: 1-713-369-1750

Sector Name: Services
Industry Name: Business Services

Employees: 964
Market Cap (Mil) $: 333.989
Complete Financials: Sep 2005
Updated: 02/03/2006
Earnings Announcements:

Key Ratios & Statistics

Price & Volume	
Recent Price $	4.61
52 Week High $	5.42
52 Week Low $	3.38
Avg Daily Vol (Mil) (RTMA)	4.381
Beta	0.48
Share Related Items	
Mkt. Cap. (Mil) $	333.989
Shares Out (Mil)	72.449

Valuation Ratios	
Price/Earnings (TTM)	N/A
Price/Sales (TTM)	1.00
Price/Book (MRQ)	1.75
Price/Cash Flow (TTM)	N/A
Per Share Data	
Earnings (TTM) $	-.88
Sales (TTM) $	9.60
Book Value (MRQ) $	2.64

Float (Mil)	29.700	Cash Flow (TTM) $	.09
		Cash (MRQ) $	0.00
Dividend Information			
Yield %	8.68	**Mgmt Effectiveness**	
Annual Dividend	.40	Return on Equity (TTM)	-1.44
Payout Ratio (TTM) %	0.00	Return on Assets (TTM)	-1.26
		Return on Investment (TTM)	-1.44
Financial Strength			
Quick Ratio (MRQ)	1.65	**Profitability**	
Current Ratio (MRQ)	1.71	Gross Margin (TTM) %	19.21
LT Debt/Equity (MRQ)	134.76	Operating Margin (TTM) %	10.04
Total Debt/Equity (MRQ)	138.27	Profit Margin (TTM) %	-1.96

Mil = Millions RTMA = Rolling Three Month Average
TTM = Trailing Twelve Months MRQ = Most Recent Quarter
Asterisk (*) indicates numbers are derived from Earnings Announcements
Pricing and volume data as of 02/03/2006

DIVISION OF CORPORATION FINANCE
INFORMAL PROCEDURES REGARDING SHAREHOLDER PROPOSALS

The Division of Corporation Finance believes that its responsibility with respect to matters arising under Rule 14a-8 [17 CFR 240.14a-8], as with other matters under the proxy rules, is to aid those who must comply with the rule by offering informal advice and suggestions and to determine, initially, whether or not it may be appropriate in a particular matter to recommend enforcement action to the Commission. In connection with a shareholder proposal under Rule 14a-8, the Division's staff considers the information furnished to it by the Company in support of its intention to exclude the proposals from the Company's proxy materials, as well as any information furnished by the proponent or the proponent's representative.

Although Rule 14a-8(k) does not require any communications from shareholders to the Commission's staff, the staff will always consider information concerning alleged violations of the statutes administered by the Commission, including argument as to whether or not activities proposed to be taken would be violative of the statute or rule involved. The receipt by the staff of such information, however, should not be construed as changing the staff's informal procedures and proxy review into a formal or adversary procedure.

It is important to note that the staff's and Commission's no-action responses to Rule 14a-8(j) submissions reflect only informal views. The determinations reached in these no-action letters do not and cannot adjudicate the merits of a company's position with respect to the proposal. Only a court such as a U.S. District Court can decide whether a company is obligated to include shareholder proposals in its proxy materials. Accordingly a discretionary determination not to recommend or take Commission enforcement action, does not preclude a proponent, or any shareholder of a company, from pursuing any rights he or she may have against the company in court, should the management omit the proposal from the company's proxy material.

March 28, 2006

Response of the Office of Chief Counsel
Division of Corporation Finance

Re: Synagro Technologies, Inc.
Incoming letter dated February 7, 2006

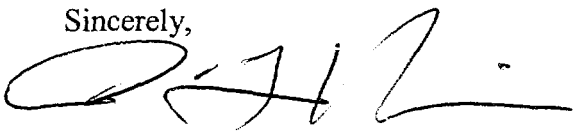
The proposal requests that the board of directors report on the environmental, health and safety impacts of New York Organic Fertilizer Company on the South Bronx, New York community.

We are unable to concur in your view that Synagro may exclude Sustainable South Bronx as a co-proponent of the proposal under rule 14a-8(f). We note in particular that you did not assert that the aggregated holdings of the co-proponents do not satisfy the minimum share ownership requirements specified by rule 14a-8(b). Accordingly, it is our view that Synagro may not omit Sustainable South Bronx as a co-proponent of the proposal in reliance on rules 14a-8(b) and 14a-8(f).

We are unable to concur in your view that Synagro may exclude the proposal under rule 14a-8(i)(5). Accordingly, we do not believe that Synagro may omit the proposal from its proxy materials in reliance on rule 14a-8(i)(5).

We are unable to concur in your view that Synagro may exclude the proposal under rule 14a-8(i)(10). Accordingly, we do not believe that Synagro may omit the proposal from its proxy materials in reliance on rule 14a-8(i)(10).

Sincerely,



Mark F. Vilardo
Special Counsel